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INDOOR AIR QUALITY IN PUBLIC BUILDINGS

VOLUME I

by

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SECTION 1
INTRODUCTION

An association of human exposure to indoor air contaminants and adverse health effects has been suspected for some time. Generally, total human exposure to air contaminants is believed to stem from personal habits (e.g., smoking), the occupational environment, and the outdoor and indoor environment. Research has focused on identifying air pollutants in each of these categories. The research performed includes an assessment of emission sources for each category, physical and chemical characteristics, and levels and methods for control of the pollutants. The presence of indoor air contaminants and exposure to populations is of most concern to persons spending from 70 to over 90% of their time in indoor environments. Furthermore, the importance of indoor air quality will become greater as measures to conserve energy, such as reduced ventilation rates, are instituted in buildings.

Previous research efforts related to indoor air quality have concentrated on several criteria pollutants (CO_2, NO_2, particulates) and several uniquely indoor pollutants (radon, formaldehyde, asbestos) in private residences. Large numbers of hazardous air pollutants or noncriteria compounds (solvents, pesticides, PCBs, polynuclear aromatic compounds-PNAs) that may exist in buildings where large numbers of people spend much of their time (schools, office buildings, hospitals) have not been investigated comprehensively. Little is known regarding pollutant emission rates from building materials, furnishings, or maintenance supplies. The influence of air exchange rates and meteorological conditions on pollutant concentrations in large public access buildings is not well-understood. This monitoring and analysis effort to characterize air quality in several types of buildings was undertaken to answer some of these questions.

The basic goal of the study was to collect monitoring data on the chemical composition of indoor air as a function of the sources and modifying factors present in the indoor environment.

During monitoring, three types of occupied buildings were selected for study including elderly homes, schools, and office buildings. These represent building types where the occupants spend a major portion of their time indoors. Furthermore, in the case of schools and elderly homes, the occupants may be more suceptible to the adverse health effects of high pollutant levels. A total of six field monitoring trips were performed; one each to a school and to two elderly homes. A new office building was monitored immediately upon completion and then one and five months later to determine the effect of building age on indoor air pollution levels.

A broad range of organic and inorganic compounds in both the particulate and vapor phases were included in the monitoring program. Information on many ancillary variables, such as meteorological conditions, air exchange rates, building material composition, cleaning and maintenance materials in use, heating, ventilating, and air conditioning operating parameters, and other related information, were collected concurrently.

In a parallel study, emission rates of chemicals from building materials were measured. The materials were chosen according to their prevalence in the specific study buildings and to the extent they may have been responsible for the chemicals observed during the monitoring phase. Thus, a specific aim was to assimilate information on the material content (e.g., carpets, drapes, furniture, varnishes, waxes, etc.) and the approximate surface area to volume ratio of these materials in each facility. Emission rates for volatile organic chemicals were also measured by a chamber study. Results of this study were compared to the field monitoring data in an attempt to relate potential sources with measured pollutant levels.

SECTION 2
SUMMARY AND CONCLUSIONS

The purpose of this indoor air study was to survey a variety of public buildings where occupants spend much of their time indoors. Activities associated with this survey included sampling and analysis for volatile organics, pesticides/PCBs, formaldehyde, inhalable particulates, elements, carbon monoxide, and nitrogen dioxide. Air exchange rates at the monitoring locations were also measured. Sampling was performed in four buildings: two elderly homes, a school, and an office building. The office building was monitored immediately after construction and again at one and five months after occupation. At each building, sampling was performed at 3 to 5 indoor locations and a single outdoor location. Samples were collected over a two to three day period. Because so few samples were collected at each location and because locations were selected to represent a diversity of indoor environments within each building, it was difficult to draw definite conclusions from the data; however, a number of trends were apparent as discussed below.

Volatile Organics

Full qualitative GC/MS interpretation was performed on 16 indoor and outdoor samples from each of the four buildings. Over three hundred organic compounds were identified. Aromatic and aliphatic hydrocarbons were the most predominant species. However, volatile chlorinated hydrocarbons, esters, alcohols, phenols, ketones, aldehydes, ethers, epoxides, carboxylic acids and sulfur and nitrogen-containing compounds were also identified.

Quantitative analysis was performed for eighteen volatile target compounds. In general, the percentage of air samples with measurable concentrations (i.e., % above the quantifiable limit) was high for fifteen of the eighteen chemicals in indoor air samples. For the three trips to the office building, all of the air samples contained measurable amounts of

1,1,1-trichloroethane, benzene, ethylbenzene, *o*-xylene, *m,p*-xylene, *n*-undecane, and *n*-dodecane. For the school, the percent measurable was 100% indoors for all of the volatile organics except chloroform and chlorobenzene. For elderly home-1, the percent measurable was 100% for all volatiles except trichloroethylene, styrene and *n*-dodecane. The percent measurable for elderly home-2 was 100% except for trichloroethylene, styrene, *m,p*-dichlorobenzene, and *o*-xylene.

For all field monitoring trips, the ratio of indoor to outdoor percent measurable for each target was close to one. This indicated that the same volatile targets were found in both the indoor and outdoor air.

The indoor air in the newly constructed office building had the highest concentrations for most of the volatile targets. However, by the third trip the concentrations had decreased considerably. For example, the median concentration of ethylbenzene dropped from 80 to approximately 4 $\mu m/m^3$; of *n*-decane, 310 to 3 $\mu m/m^3$; of 1,1,1-trichloroethane, 290 to 40 $\mu g/m^3$; of *m,p*-xylene, 150 to 12 $\mu g/m^3$; of *n*-undecane, 150 to 10 $\mu g/m^3$; and of *n*-dodecane, 45 to 8 $\mu g/m^3$. For carbon tetrachloride, chlorobenzene, styrene, benzene, and tetrachloroethylene, the concentrations were low during the first trip (> 5 $\mu g/m^3$) and remained low during all three trips. Conversely for chloroform and trichloroethylene, the indoor air concentrations were low during the first trip and increased significantly by the third trip. Chloroform was the one volatile target which showed a substantial change in outdoor concentration over the three sampling trips. Both indoor and outdoor chloroform concentrations increased from 1 to approximately 12 $\mu g/m^3$ between the second and third trip to the office building. Indoor/outdoor median concentration ratios for target volatiles were generally very high for the first trip (20-50 units) and had dropped significantly by the third trip (2-10 units).

Indoor air concentrations of volatile organics for the school, elderly home-1, and elderly home-2 were much lower (generally less than 5 $\mu g/m^3$) than found in the new office. For the school, there were no significant differences between day and night or between indoor and outdoor mean concentration levels. For the elderly home-1, the outdoor concentrations were generally greater than the indoor concentrations with the exception of styrene, and this difference was not considered significant. A significant difference in indoor versus outdoor concentration was apparent at the elderly home-2 for four compounds: chloroform, n-decane, n-undecane, and n-dodecane. Chloroform exhibited higher indoor concentrations while the alkanes had higher outdoor concentrations.

Daytime indoor air concentrations were higher than nighttime indoor air concentrations for the trips to the office and both elderly homes. This is probably due to compounds being released into the air from daytime activities.

Formaldehyde

Measurable concentrations of formaldehyde were found at only a few sampling locations during the six field monitoring trips. Quantitation limits were generally less than 15 ppb. No conclusion could be drawn from the limited data.

Inhalable and Respirable Particulates

Inhalable and respirable particulate concentrations were generally low ($< 10\ \mu g/m^3$) at sampling locations where smoking was not observed. At locations where cigarettes were smoked, levels ranging from 4-100 $\mu g/m^3$ were measured.

Concentration levels of respirable particulate measured using the piezobalance versus the dichotomous sampler agreed fairly well at nonsmoking locations. With the piezobalance, an increase in respirable particulate levels resulting from a single cigarette could be measured.

Pesticides/PCBs

Significant problems occurred during the analysis of field samples using packed column GC/ECD. Many of the field samples contained high levels of air contaminants, which interfered with the analysis of the target pesticides/PCBs. This led to a number of samples that could not be quantitated. Further, when background contaminants resulting from other organics in air samples are high, identification becomes subjective and may lead to significant errors. Therefore, caution should be exercised in interpreting data presented for the pesticides and PCBs. Results for the pesticides/PCBs are not presented in the body of this report, rather they have been included in the Appendix.

Elements

The only elements consistently detected at measurable levels were "crustal" ones such as silicon, calcium, and iron. Whether they were more prevalent indoors or outdoors varied by trip and building. For the office building, concentrations were highest on the first trip and very low by the third trip. Concentration levels and percent measurable were generally very low at both elderly homes. The most interesting data were from the school where silicon, calcium, and iron were measurable indoors only during the daytime. Lead and bromine followed an entirely different pattern and were found mainly outdoors.

Nitrogen Dioxide

Nitrogen dioxide was measured at one indoor and one outdoor location at the elderly home-1, using chemiluminescent monitors. Daily mean averages for the outdoor samples ranged from 18.7 to 31.1 ppb, and 22.7 to 25.0 ppb for the indoor samples. A comparison of concentrations determined using passive NO_2 badges with chemiluminescent monitors showed good agreement for the outdoor samples; indoor badge measurements were low compared to the monitors.

Carbon Monoxide

Field data generated using GE carbon monoxide monitors were compiled for the sampling locations at the elderly home-1. No CO was detected at any of these locations, due to static electricity (generated by low humidities) affecting the cable connectors of the strip chart recorders.

CHAMBER STUDY

To assess source contributions that might have been responsible for elevated levels of volatile organics in the new office building, an inventory of various building materials was compiled, and consumer products used were noted. From these listings, several materials were selected for a headspace screening of volatile organic chemicals emitted. The materials that accounted for the target chemicals found in the monitoring study were then selected for an emission rate study. Upon examining the headspace results for various materials, only small quantities of all of the target chemicals except _n_-decane and _n_-undecane were found in Talon-G, Armstrong fissured minaboard ceiling, Ficam-W, carpet, nonsmooth carpet, sheetrock, and Borden E8825 film. The remaining materials, which were pesticides and cleaning compounds, had trace to substantial quantities of the target chemicals. In particular, very high levels of 1,1,1-trichloroethane were detected in the insecticide PT-250.

During the chamber study, the highest concentrations of chemicals were found when the cleaning agents and an insecticide had been applied to surfaces. High levels of chloroform, 1,2-dichloroethane, 1,1,1-trichloroethane, and carbon tetrachloride were observed as well as lower quantities of dichlorobenzenes.

Emission rates calculated for various selected materials clearly suggest that many of the volatile organics may originate from cleaning agents. The high levels of 1,1,1-trichloroethane are consistent with the previously observed high values in the new office building. Also, the higher indoor air levels of other halogenated chemicals observed in the new office building may be attributed to similar sources with high emission rates. An interesting observation is the rather ubiquitous emission(s) of n-decane and n-undecane.

SECTION 3
RECOMMENDATIONS

As a result of this Indoor Air Study, several recommendations can be made about the design and implementation for similar studies. Recommendations on methods for sampling and analyses have also been included.

STUDY DESIGN

This study was intended to serve as a broad survey for monitoring a variety of organic and inorganic chemicals in public access buildings. Of necessity, this study monitored several different building types with diverse environments within a building. There was never sufficient data to allow statistical conclusions to be made about the indoor air quality at a single type of indoor environment. It is recommended that for future studies, hypotheses be formulated, i.e., levels of organic pollutants are high in rooms containing office equipment, then the buildings and locations in the building, pollutants, and monitoring strategy would be selected to test these hypotheses.

FIELD SAMPLING

1. If new buildings are to be monitored, careful consideration should be given to the construction and occupancy schedule for the building. Unfortunately, many new buildings are being "finished off" at the same time that the building is being occupied. This does not allow a suitable period for monitoring the new unoccupied building. Sampling results will often reflect finishing and moving activities rather than emissions from new building materials.
2. The number of pollutants for monitoring should be reduced in order to minimize space and noise burden imposed at each sampling location. As an alternative to individual monitors, a compact sampling unit could be designed for collecting multiple sorbent or filter samples simultaneously.

3. Results of this study demonstrated that in many cases indoor air pollution results from activity patterns and product use. Therefore, more in-depth and accurate information should be collected on specific activities.
4. Specific details of the air handling systems must be acquired before sampling in order to effectively perform air exchange measurements. It should be noted that the measurements performed for this study determined exchange with the outside air. For modelling pollutant sources within a building, air exchange rates with the rest of the building air would also be required.
5. Participants should be well-informed of the sampling requirements in a selected building. Throughout this study, many of the occupants in the buildings studied became uncooperative when the sampling burden became apparent.
6. Sample custody sheets were adapted from a personal monitoring program. These procedures should be streamlined in order to reduce the paperwork required in the field. The large amount of paperwork required an additional person in the field during each sampling trip.

SAMPLING AND ANALYSIS PROCEDURES

1. Response factor control limits for GC/MS analysis of volatile organics should be made more rigorous.
2. Methods for the sampling and analysis of formaldehyde should be developed to allow for a 12 hr sampling period.
3. The use of the dichotomous sampler for inhalable particulates is unsuitable for indoor air sampling because of the size of the equipment and the noise generated during operation.
4. Simple, reliable passive monitors for monitoring nitrogen dioxide and carbon monoxide for short sampling periods should be developed.
5. "Streakers" should not be used for the collection and analysis of indoor air samples for elemental analysis. Not only is the equipment noisy and large, but insufficient sample is collected over a 1 hr period to provide adequate detection limits. Considerably larger sample volumes are required to detect elements in indoor air.

6. Pesticides/PCBs should be analyzed using capillary column chromatography. This should help to minimize problems with interfering compounds.
7. Air exchange rates should be acquired over the same periods (12-24 hr) as the samples.
8. Standard methods for sampling and analysis should be developed such that data are comparable between field studies and projects.

QUALITY ASSURANCE

1. Methods for preparing control samples for elements and inhalable particulates should be investigated.
2. Performance evaluation samples should be prepared and analyzed for all of the parameters monitored rather than just volatile organics.
3. The use of external QA laboratories should be reevaluated for this type of program. During this program, the QA laboratory was sent two field samples, two field controls, two field blanks, and several performance evaluation samples for every 12 samples collected. Since sample analysis costs range from $200-400 per sample, a large sum of money is being spent to acquire very little data. The use of extensive performance evaluation samples would provide less costly and more reliable data control.

STATISTICAL ANALYSIS

Additional analysis may be needed on the data for volatile organics to evaluate additional hypotheses concerning specific building types, pollution sources, occupancy habits, etc.

CHAMBER STUDIES

Standard methods for collecting, storing, scouting, sampling, and analyzing materials for emission rate studies should be established. Use of smaller chambers could provide emission rate data at a lower cost.

SECTION 4

SAMPLING AND SAMPLE PREPARATION

SAMPLE DESIGN

The eight groups of chemicals monitored during this research program are listed in Table 1. Sampling/analytical methods and monitoring schedules are also given. Table 2 presents the matrix depicting the monitoring strategy and total number of samples planned throughout this study. An office building in Research Triangle Park, NC, a primary school in Washington, DC, and two elderly homes, also in Washington, DC were selected for monitoring. The number of sampling locations per building, samples collected per day, monitoring days, and repeat visits are indicated. In all facilities, an outside location near the air intake was monitored. The indoor locations were selected on-site to represent a variety of indoor environments. All monitoring employed fixed-site stations. Longitudinal and daily monitoring schedules are given in Tables 3 and 4.

All samples were collected using the protocols described in the Draft Work Plan, Part II: Analytical Protocols. In this section, details of sample preparation and sampling for each sampling site and each parameter collected are given. Information on sampling sites, collection method, method validation, and QC samples has been included.

FIELD SAMPLING

Elderly Home-1

Collection of field samples at elderly home-1 took place in Washington, DC, from March 23 to 26, 1983. Six sampling locations, one outside and five inside, were monitored during that time period. A brief description of these sampling locations is given in Table 5. A more detailed description is presented in Section 5. The number of samples scheduled for collection versus those actually collected is given in Table 6.

TABLE 1. MONITORING PARAMETERS

Chemical Groups	Sampling Method/Analytical Method	Monitoring Schedule
Group I	Collection on Tenax; analysis by GC/MS	Consecutive 12 h samples
chloroform		
1,2-dichloroethane		
1,1,1-trichloroethane		
carbon tetrachloride		
trichloroethylene		
tetrachloroethylene		
chlorobenzene		
benzene		
1,1,2,2-tetrachloroethane		
ethyl benzene		
p-xylene		
o-xylene		
styrene		
o-dichlorobenzene		
p-dichlorobenzene		
n-decane[a]		
n-undecane[a]		
n-dodecane[a]		
Group II	Collection on 10 μ particulate matter filters	Consecutive 24 h samples
inhalable particulates	Piezobalance Miniram	Continuous automated monitoring
Group III	Collection on polyurethane foam; solvent extraction; analysis by GC/ECD	Consecutive 24 h samples
HCB		
α-BHC		
β-BHC		
γ-BHC		

(continued)

TABLE 1. (cont'd.)

Chemical Groups	Sampling Method/Analytical Method	Monitoring Schedule
Group III (cont'd.)		
Heptachlor		
Heptachlor epoxide		
trans-Nonachlor		
Oxychlordane		
tech. Chlordane		
p,*p*'-DDT		
p,*p*'-DDE		
p,*p*'-DDD		
PCBs		
Group IV		
NO_2	Chemiluminescent monitors	Continuous monitoring over sampling period
	Passive badge; colorimetric analysis	Consecutive 24 h samples
Group V		
formaldehyde	Collection on molecular sieve; analysis by paraosaniline method	30 minute sample once each day
Group VI		
Elements	Collection on particulate matter filters (streakers); analysis by photon induced X-ray emission over 1 or 4 h time periods	Continuous automated collection over sampling period
	Collection on particulate matter filters; analysis by photon induced X-ray emission over 24 h time period	Consecutive 24 h samples

(continued)

TABLE 1. (cont'd.)

Parameters	Sampling Method/Analytical Method	Monitoring Schedule
Group VII CO	Electrochemical	Continuous monitoring over sampling period
Group VIII air exchange	Tracer gas; analysis by GC/ECD	SF_6 release; collection of air samples at 15 min intervals over a 2 h period

[a] Added as targets while the study was in progress.

TABLE 2. MATRIX EXHIBITING MONITORING STRATEGY

Parameter Monitored	Facility	No. Locations/ Bldg.	No. Samples/ Day	No. Days	Repetition No.
Volatile Organics	Office	6	2	2	3
	School	4	2	3	1
	Elderly home-1	6	2	3	1
	Elderly home-2	5	2	3	1
Inhalable Particulates	Office	4	1	2	3
	School	0	0	0	0
	Elderly home-1	6	1	3	1
	Elderly home-2	5	1	3	1
Pesticides/PCBs	Office	6	1	2	3
	School	4	1	3	1
	Elderly home-1	6	1	3	1
	Elderly home-2	5	1	3	1
Nitrogen dioxide	Office	6	0	0	0
	School	4	0	0	0
	Elderly home-1	6	1[a]	3	1
	Elderly home-2	5	0	0	0
Formaldehyde	Office	6	1	2	3
	School	4	1	3	1
	Elderly home-1	6	1	3	1
	Elderly home-2	5	1	3	1

(continued)

TABLE 2. (cont'd.)

Parameter Monitored	Facility	No. Locations/ Bldg.	No. Samples/ Day	No. Days	Repetition No.
Elements	Office	6	1	2	3
	School	4	1	3	1
	Elderly home-1	6	1	3	1
	Elderly home-2	5	1	1	1
Carbon monoxide	Office	6	0	0	0
	School	4	0	0	0
	Elderly home-1	6	1[a]	0	0
	Elderly home-2	5	0	3	1
Air-exchange Rates	Office	4	2	2	1
	School	3	2	3	1
	Elderly home-1	5	2	2	1
	Elderly home-2	4	2	3	1

[a] Hourly averages were obtained.

TABLE 3. LONGITUDINAL MONITORING SCHEDULE

Facility	Month[a]											
	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN
Office building							2 da	2 da			2 da	
School				3 da								
Elderly home-1		3 da										
Elderly home-2												3 da

[a] From February 1983 to January 1984.

TABLE 4. APPROXIMATE DAILY MONITORING SCHEDULE FOR ALL FACILITIES

Parameter	Start-Finish Time Period (Sampling Time)
1. Volatile Organics	0700-1800h(11h), 1800-0700(13h)
2. Inhalable Particulates	1800h(24h)
3. Pesticides/PCBs	1800h(24h)
4. Nitrogen dioxide	1800h(24h)
5. Elements	1800h(24h)
6. Carbon monoxide	1800h(24h)
7. Air-Exchange rate	0900-1100h(2h)
8. Formaldehyde	1800-1830h(0.5h)

TABLE 5. FIELD SAMPLING LOCATION WITHIN ELDERLY HOME-1

Location	Description
1	Rooftop: far west corner of building
2	5th floor lounge: near hallway
3	3rd floor lounge: near outside glass doors
4	Dining room: near outer glass doors
5	4th floor occupied room: nonsmoker
6	1st floor occupied room: smoker

TABLE 6. SAMPLE COLLECTION AT THE ELDERLY HOME-1

	Volatile Organic	Inhalable Particulate (Coarse & Fine)	Pesticide/ PCBs	Formaldehyde	Elements[a] (Nucleopore & Impactor)	Carbon Monoxide (Monitor)	NO (Badge)	NO (Monitor)	SF_6[b]
Field Samples (scheduled/collected)	36/36	36/36	18/18	18/17	18/18	6/2	18/18	2/2	20/17
Field Duplicates (scheduled/collected)[c]	4/4	2/2	2/2	2/2	2/2	2/1	3/3	-[d]	2/4
Field Blanks (scheduled/utilized)	4/4	3/3	3/3	3/3	6/6[e]	-	2/2	-	-
Field Control Sets (scheduled/utilized)	4/4	-	3/3	3/3	-	-	-	-	-
Lab Blanks (scheduled/utilized)	4/4	4/4	4/4	3/3	-	-	4/4	-	-
Lab Control Sets (scheduled/utilized)	4/4	-	4/4	3/3	-	-	-	-	-
Total	56/56	45/45	34/34	31/31	26/26	8/3	27/27	2/2	22/21

[a] Three days of analysis per filter.

[b] Six syringes collected per sampling period.

[c] Does not include QA samples.

[d] Not scheduled.

[e] A blank portion of every filter was analyzed.

Volatile Organics--

Collection method. Volatile organic compounds were collected from air samples by passing the air through a glass sampling cartridge (10 x 1.4 cm i.d.) containing 6 cm of 35/60 mesh Tenax. A Dupont-Model P-125 A pump was used for sample collection. Flow rates were adjusted such that a total of approximately 0.025 m^3 of air was collected for each sample. Flow rates were adjusted to approximately 0.03 L/min for a 12 h collection period.

Preparation of Sampling Materials. Tenax used during previous field monitoring studies was recycled for use in the Indoor Air Study field effort. The Tenax was extracted in a Soxhlet apparatus for 24 h both with methanol and n-pentane prior to preparation of sample cartridges. After extraction, the Tenax was dried under a nitrogen atmosphere for 24 h, and then in a vacuum oven at 100°C for 24 h at 28 inches of water. The Tenax was sieved to provide a 35/60 particle size range. After packing, each cartridge was desorbed at 270°C with a purified helium purge for 5 h.

Twenty-four hours after the final desorption step, 10% of the Tenax cartridges were analyzed by thermal desorption/GC/FID to determine the background contamination. Data for these checks are presented in Table 7. The background checks for these cartridges showed no contamination in the chromatographic region of the target compounds as shown in Figure 1.

Preparation of QC sets. Eight QC sets each consisting of one blank and two spiked controls were prepared. One spiked control contained those target compounds which could be loaded from a permeation system. The other control contained target compounds loaded using flash evaporation. Compounds and amounts loaded on each cartridge are shown in Tables 8 and 9. Chromatograms (GC/FID) of control cartridges from the permeation and flash system are shown in Figures 2 and 3.

Four of the QC sets were used for field QC sets while four served as lab QC sets.

Sampling protocol. The sampling protocol sheet given in Figure 4 was employed for acquiring information regarding the sampling for volatile organics. This sheet was also used for the collection of pesticides/PCBs, elements, and formaldehydes.

TABLE 7. BACKGROUND CHECK DATA OF TENAX CARTRIDGES USED AT THE ELDERLY HOME-1

Area Counts[a] x10^3	Date[b] Desorbed	Date Run	Comments
9,689.2	3-14	3-17	high hydrocarbon background;[c] no interference with target compounds
3,626.2	3-16	3-18	
4,991.8	3-16	3-17	
2,867.6	3-16	3-18	
6,064.8	3-16	3-18	high hydrocarbon background; no interference with target compounds
6,176.0	3-16	3-18	high hydrocarbon background; no interference with target compounds
4,774.3	3-18	3-19	
5,220.1	3-16	3-19	high hydrocarbon background; no interference with target compounds (group desorbed again)
10,456.0	3-18	3-19	high hydrocarbon background; no interference with target compounds (group desorbed again)
8,292.9	3-18	3-19	high hydrocarbon background; no interference with target compounds
4,710.1	3-18	3-19	high hydrocarbon background; no interference with target compounds
2,152.9	3-20	3-22	
1,094.6	3-21	3-22	

[a] Area counts are total area × 10^3 through a 40 min run discounting the solvent peak.

[b] All the cartridges were desorbed twice; the dates correspond to the last desorption.

[c] _n_-Decane, _n_-undecane, and _n_-dodecane had not yet been designated as target compounds.

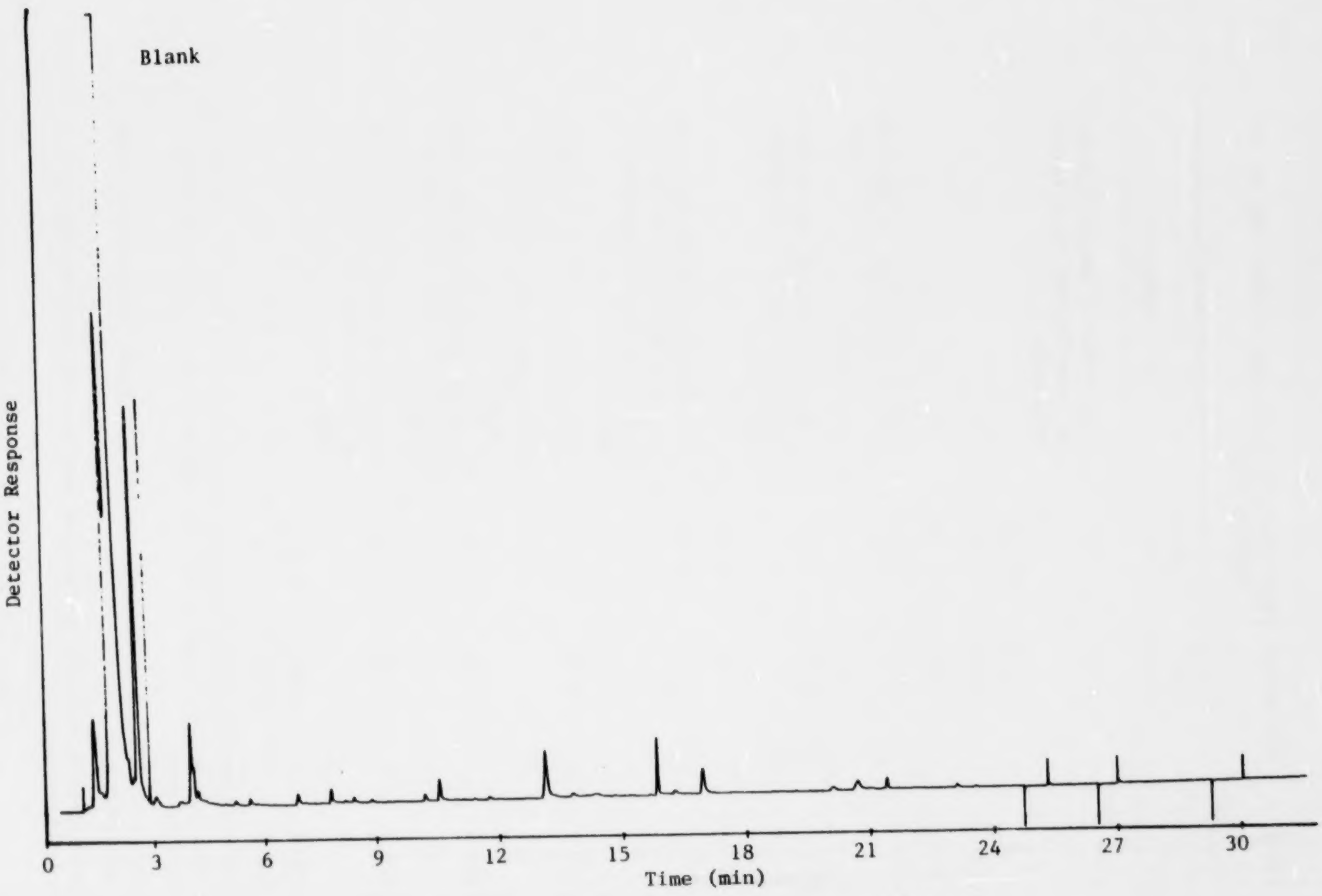

Figure 1. Tenax background check - GC/FID.

TABLE 8. STANDARDS LOADED FROM PERMEATION SYSTEM

Compound	Amount (ng/cartridge)
Chloroform (#1)	139
1,2-Dichloroethane (#2)	392
1,1,1-Trichloroethane (#3)	211
Carbon tetrachloride (#4)	239
Trichloroethylene (#5)	480
Tetrachloroethylene (#6)	383
Chlorobenzene (#7)	166
Benzene (#8)	362
1,1,2,2-Tetrachloroethane (#9)	480

TABLE 9. STANDARDS LOADED FROM FLASH SYSTEM

Compound	Amount (ng/cartridge)
Ethylbenzene (#11)	346
p-Xylene (#12)	344
o-Xylene (#13)	352
Styrene (#10)	362
o-Dichlorobenzene (#15)	260
p-Dichlorobenzene (#14)	260

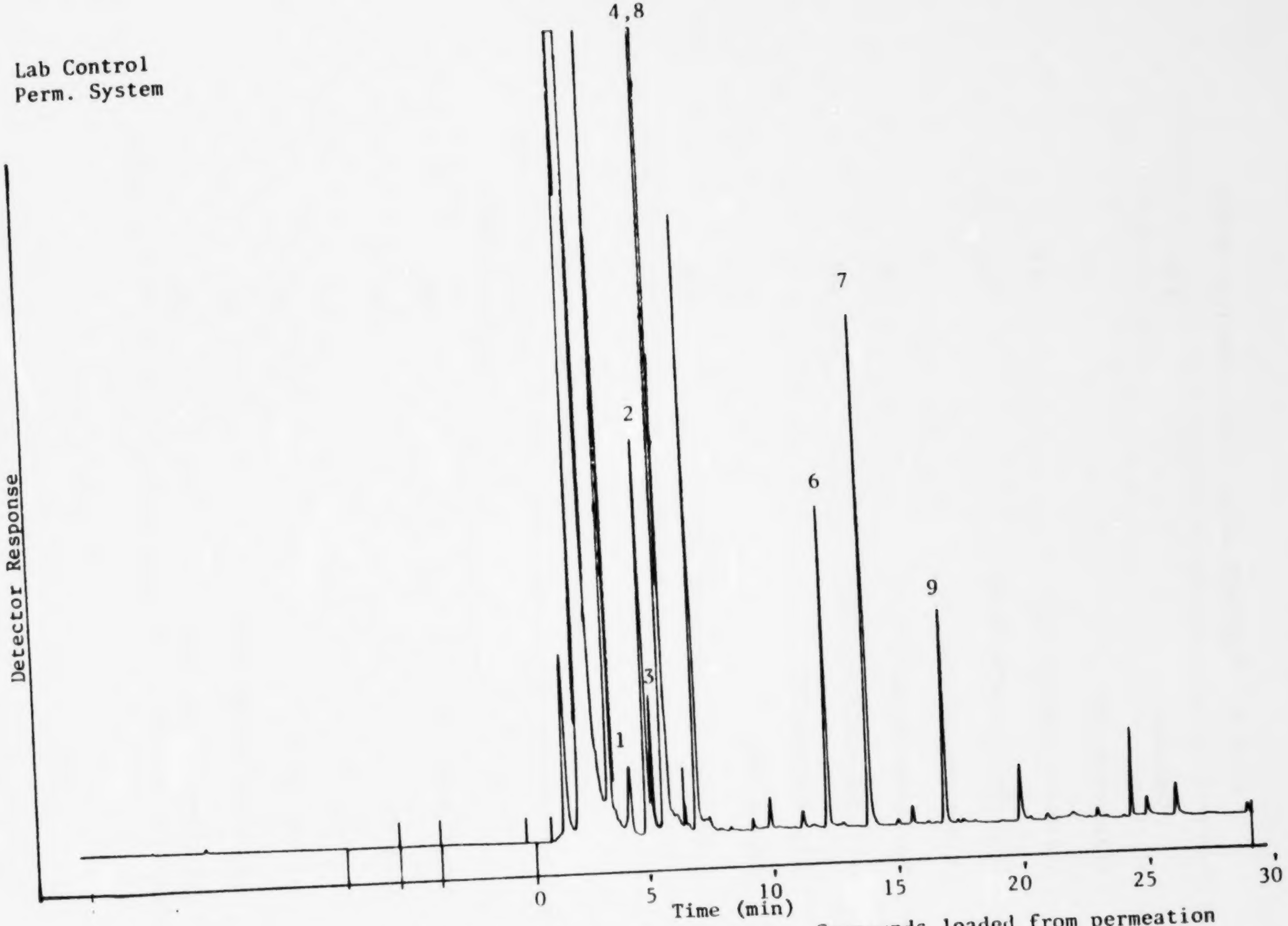

Figure 2. Lab control cartridge - GC/FID chromatogram. Compounds loaded from permeation system. See Table 8 for identity of peaks.

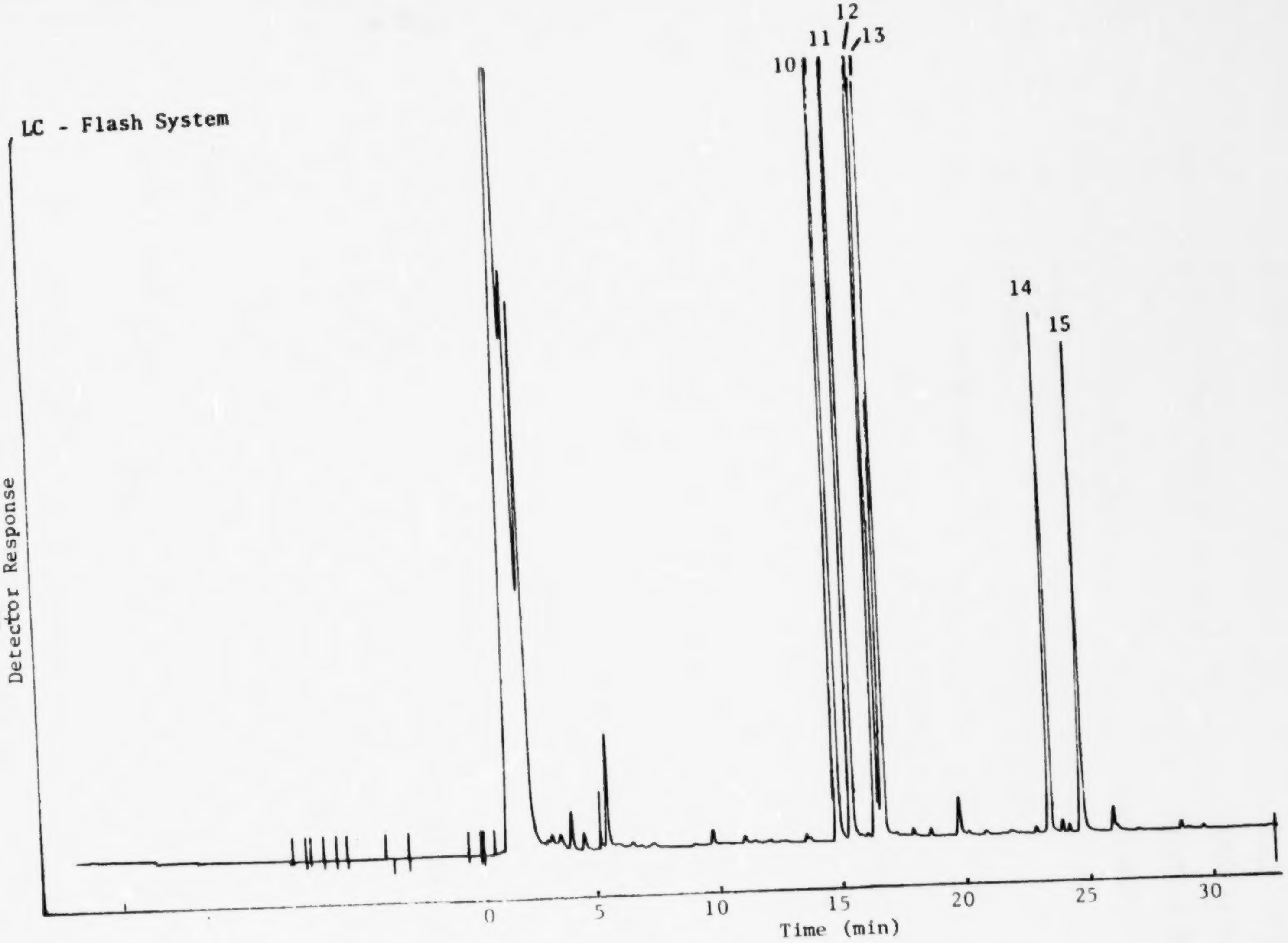

Figure 3. Lab control cartridge - GC/FID chromatogram. Compounds loaded from flash system. See Table 9 for identity of peaks.

FIELD SAMPLING PROTOCOL SHEET - INDOOR AIR STUDY

Date: ______________________

SAMPLE CODE: ______________________________________

AIR SAMPLING

Pump Model:	__________	Serial Number:	__________
Time (Initial):	________	Flow Rates (Initial):	_____
(Final):	________	(Final):	_____
Total Time:	__________	Avg. Flow Rate:	________

Total Volume Sampled: ________________

Temperature (^{o}F): __________________

Description of Fixed Site Location (include sketch):

GENERAL REMARKS

Figure 4. Sampling protocol form for volatile organic, pesticide/PCB, formaldehyde, and element samples.

FIELD SAMPLING PROTOCOL SHEET - INDOOR AIR STUDY

Date: ____________________

Sample Code: ____________________

Air Sampling

Pump Model: ____________________ Serial Number: ____________________

Filter Type (circle appropriate filter): Coarse Fine

Dichot Dichot

Time (initial): ____________ Rotameter Flow Rate (initial): ____________

(final): ____________ (final): ____________

Total Time (min): ____________ Average Flow Rate: ____________

Actual Flow Rate (m^3/min): ____________

Total Volume Sampled: ____________________

QC Check, %: ____________________

Location of Fixed Site Sampler (include sketch):

Remarks:

Figure 5. Example of field sampling protocol sheet, inhalable particulates.

Inhalable and Respirable Particulates--

Dichotomous Samplers.

Collection method--Inhalable (IP) and Respirable (RSP) particulates were collected using the schedule described in Table 2 with a low flow rate (16.7 L/min) dichotomous sampler. Samples were collected over a 24 h period to give a sample size of ~24 m^3. IP are defined as those particles with less than 15 μm aerodynamic diameter (a.d.). RSP are defined as those particles with a diameter of $<$ 3.5 μm. The samplers used for this project divided the total IP sample into fine or respirable particulate (0 to 2.5 μm a.d.) and coarse inhalable particulate (2.5 to 15 μm a.d.) fractions that were collected on separate 37 mm diameter 2 μm pore size Teflon® filters. For dichotomous samplers, particle size separation was accomplished by pseudo-impaction into an air stream of differing velocity rather than onto an impaction surface.

At the outset of the project, ten complete Sierra Model 244 E dichotomous samplers were received from EPA. Each unit was calibrated and checked at EPA before being issued to RTI. Rotometer calibration tables based on the average temperature and pressure of the sampling area (Washington, DC) for each unit were provided. A field calibration orifice and the calibration tables were used for daily calibration of the Sierra dichotomous samplers in the field. Initial calibration was performed using 1 L and 10 L dry gas meters.

Field samples were collected according to the protocol in the Draft Work Plan. No unusual problems were encountered. Flow measurements obtained for the Sierra Dichotomous samplers at indoor sites were calculated from the "Summer Months" calibration table which was developed by using 23.7°C as the average temperature. This temperature, and therefore the "Summer Months" calibration table, most closely matched the indoor temperatures of this sampling site.

Preparation of QC sets--Seven QC sets were prepared. Each set consisted of one blank filter for both the respirable and inhalable particulates. No control filters were prepared. Three sets were used for field blanks while four sets served as laboratory blanks.

Sampling protocol--The sampling protocol sheet given in Figure 5 was employed for acquiring sampling information for respirable and inhalable particulates.

Piezobalance. Quasi-realtime measurements of respirable ($< 3.5\ \mu m$) particles were made using the TSI Model 3500 Piezobalance®. This device uses the piezo-electric principle to measure masses as small as 10^{-9} g. Particles are pumped at 1 L/min through an inlet leading to an impactor and an electrostatic precipitator. Nearly all particles $< 3.5\ \mu$ in diameter are deposited on a quartz disk oscillating at a stable resonant frequency in an electrical circuit. As the particles accumulate on the crystal, its frequency decreases directly with the mass collected. An enclosed reference crystal is used in measuring the frequency change.

Particle concentrations were displayed using an automatic 2-minute cycle. Longer measurement periods can also be selected by recording the beginning and ending frequencies and elapsed time.

The instrument has been tested using several different aerosols and has been found to respond better to moist aerosols than to dry dusts. Since rapid changes in temperature and/or humidity produce invalid readings, the instrument was allowed time to equilibrate at each new environment. When fully equilibrated, the baseline frequency is stable; however, useful data can be obtained even without complete equilibration by measuring the baseline drift before and after the measurement period and subtracting the average drift from the readings.

Recently, a "particle production" phenomenon has been observed in piezobalance measurements; that is, nonzero readings are obtained even with absolute filters attached to the inlet. The physical mechanism involved is not totally understood at present; however it can be easily neutralized by attaching a HEPA filter for a portion of the measurement period and subtracting the resultant reading from each measurement. Readings with the HEPA filter attached were taken several times daily in both smoking and nonsmoking environments.

Since the measurements made with the HEPA filter include the baseline drift, the "particle production" contribution was given by the difference between the HEPA filter readings and the baseline drift.

The Piezobalance was employed primarily to supplement the dichotomous sampler's long-term average mass concentrations by investigating short-term variations in particle concentrations. In particular, it was expected that particulate concentrations in smoking areas would reach short-term peaks well above the 24-hour average values determined by the dichotomous sampler.

Each of the five interior sampling locations listed in Table 5 were sampled. An additional nonsmoking area (the Administrator's office) and an additional smoking area (the 2nd-floor lounge) were also studied. In the smoking areas, a record was kept of the number of smokers, cigarettes smoked, and time of smoking.

Since the piezobalance is factory-calibrated, no calibration was performed during the monitoring period. A duplicate Model 3500 was operated side-by-side with the primary instrument on one day.

Pesticides/PCBs--

Collection method. Pesticides and PCBs were collected from air samples using the schedule described in Table 2 by passing air through a polyurethane foam (PUF) plug at a flow rate of 5-6 L/min. Samples were collected over a 24 h period to give a sample size of ~8 m^3. One PUF plug (5 cm x 2 cm) was used for each sample collected. RTI high volume personnel sampling pumps (BDX-30) were used for sample collection. Sample collection was performed as described in the protocol in the Draft Work Plan.

Preparation of Sampling Materials. Polyurethane foam (PUF) plugs for the collection of pesticides and PCBs were prepared immediately prior to field sampling. Sheets of PUF were cut to 2 x 5 cm cylinders with an arch punch and jig built at the Research Triangle Institute. The plugs were extracted for 72 h in acetone followed by a 72 h extraction in hexane. During Soxhlet extraction, the Soxhlet reservoir was wrapped with aluminum foil to prevent photodecomposition of the foam. After extraction, the plugs were dried in a vacuum oven at ambient temperature. Once dry, the plugs were placed in 8-dram glass vials, capped, and stored in uncoated paint cans until sampling.

Preparation of QC Sets. Seven QC sets were prepared (3 sets for the field and 4 sets for the laboratory). QC sets consisted of one spiked and one unspiked PUF plug.

Stock solutions were prepared for the following pesticides: HCB, α-BHC, β-BHC, γ-BHC, Heptachlor, Heptachlor epoxide, Oxychlordane, tech. Chlordane, p,p'-DDT, p,p'-DDE, and p,p'-DDD. Aroclor 1260 stock solution was prepared to serve as the PCB standard. Control samples were spiked with target compounds at the levels listed in Table 10.

TABLE 10. PESTICIDE/PCB CONTROLS

Compound	Mass Spiked (ng)/PUF
Hexachlorobenzene	8.70
α-BHC	7.95
β-BHC	14.85
γ-BHC	11.70
Heptachlor	7.20
Heptachlor epoxide	7.35
Oxychlordane	17.88
p,*p*'-DDT	13.44
p,*p*'-DDE	13.44
p,*p*'-DDD	10.92
tech. Chlordane	27.90
Aroclor 1260	53.10

Sample protocol. The sampling protocol sheet illustrated in Figure 4 was used for collecting samples for pesticide/PCB analyses.

Formaldehyde--

Collection method. Formaldehyde in air was collected using 10 g of pretreated 13X molecular sieve as a sorbent material. During collection, air was pulled through a 8 mm ID glass tube containing the sieve for 30 minutes at a flow rate of ~2 L/min to provide a 60 L sample. Exposed sieve material was emptied from the glass holder and stored in sealed glass bottles until analysis.

Samples were collected as described in Table 3 using the protocol in the Work Plan.

Preparation of sampling materials. To prepare sample cartridges, molecular sieve (~1 kg) was washed in deionized water to remove fines. It was next filtered under a vacuum through Whatman 5 filter paper and dried for 24 h in a vacuum oven at 180°C. Once dried, 10 gram aliquots were transferred to 20 mL serum bottles and baked in an open air oven at 100°C for twenty minutes. The bottles were removed and sealed while hot with sleeve-type stoppers. The sieve was shipped to the field in these bottles. Immediately prior to sampling, the bottle was opened, the sieve transferred to an empty glass cartridge, and the cartridge attached to the sampling unit.

Preparation of QC sets. Field and laboratory controls were spiked with formaldehyde using a flash evaporation system. For spiking, 10 g of prepared molecular sieve was transferred from the 20 mL serum bottle into a 8 mm ID x 30 cm borosilicate glass tube. The tube was placed into a fitting on the flash evaporator system and He carrier gas flow was adjusted to 60 mL/min. A 2.5 m L injection of an aqueous formaldehyde solution was injected into the flash evaporator system and loaded onto the molecular sieve for two minutes. A total mass of 18.5 µg was loaded onto each control using the above method.

Six QC sets were prepared (3 for field use and 3 for the laboratory). Each QC set consisted of a spiked and unspiked bottle of prepared molecular sieve to serve as control and blank samples, respectively.

Sample protocol. The sampling protocol sheet illustrated in Figure 4 was used for collecting samples for formaldehyde analyses.

Elements--

Collection method. Elements adhering to airborne particulates were collected on fine (0-2.5 μ) and coarse particulate (> 2.5 μ) filters using streakers provided by Florida State University. Particulates were collected via impaction using a sample flow rate of ~1 L/min. The filters were mounted on an impactor which rotated throughout the sampling period and allowed collection of discrete 1 h samples for a sample size of 60 L. Samples were collected over a 72 h period at each sampling location.

Operational difficulties encountered in the field included significant fluctuations in flow rate for three of the streakers. All units began at ~1 L/min flow rate but the flow rate for one unit dropped to under 500 mL/min after 24 h. The flow rate increased to ~1 L/min at the subsequent measurement.

Preparation of sampling materials. The apparatus (i.e., streakers, pumps, impaction stages) for collection of element samples was supplied by the PIXE Lab at Florida State University. They also prepared the filters for use.

The apparatus was tested at RTI prior to actual field use and found to be in good working order except for two nonfunctional outlet strips.

Preparation of QC sets. An exposed portion of each filter served as a field blank. Field controls were not prepared.

Sample protocol. The sampling protocol sheet illustrated in Figure 4 was used for collecting samples for elemental analysis.

Nitrogen Dioxide--

Chemiluminescent Monitors.

Collection method--Nitrogen dioxide was measured in the air using continuous chemiluminescent monitors as described in the protocol. Bendix NO_x monitors were located at sampling sites 1 and 2. Continuous monitoring for 72 h occurred without any difficulties.

Preparation of sampling materials--Nine Bendix NO_x monitors were acquired from EPA/RTP. Eight of these analyzers were calibrated by gas phase titration (GPT) prior to being issued and were found to be in acceptable condition. A cylinder of 100 ppm NO_2 was obtained for calibration purposes and was certified by the QA laboratory. Sixteen Leeds and Northrup stripchart recorders and one complete GPT system were also obtained from EPA/RTP.

Sample protocol--Examples of NO_x control charts and Field Data Audit sheet are given in Figures 6 and 7.

Quality assurance--Operation of the NO_2 monitors was audited by personnel from EPA (EMSL-RTP).

Nitrogen Dioxide Badges

Collection method--Nitrogen dioxide badges supplied by the Toyo Roshi Company were exposed at each sampling site for three consecutive 24 h periods. These badges are small (5 x 4 x 1 cm) passive collectors which operate on a diffusion/absorption principle. A filter treated with triethanolamine (TEA) absorbs NO_2 that diffuses through a series of hydrophobic fiber filters. Badges were exposed to provide a comparison between NO_2 concentration measured using this method and the chemiluminescent monitors.

Preparation of sampling materials--Badges were used directly as supplied by the manufacturer.

Preparation of QC sets--Two field blanks and four lab blanks were used as QC samples. Unexposed badges served as blank samples.

Carbon Monoxide--

Monitoring Method. The General Electric direct indicating SPE carbon monoxide (CO) detector was used to monitor readings of ambient levels of CO. This monitor operates on the principle of a fuel cell. During operation, the fuel cell provides continuous output which is formatted into time-period averages and stored in registers by the on-board electronics for acquisition at a later date.

Due to instrumental failure, field samples were collected at only 3 sampling locations. The General Electric CO Monitors exhibited highly erratic responses at all locations throughout the building. Several monitors would spontaneously trip from log mode, where ppm CO is displayed, to other program modes. Other monitors produced background noise exceeding 20 ppm CO, rendering the output useless. It is suspected that static charges within the building facilitated by very low humidity may have been responsible for disrupting the electronics of the CO monitors.

Preparation of sampling materials. All GE CO monitors for use in this air study were delivered to RTI in early March. EPA also provided 8 Leeds and Northrup stripchart recorders modified to 100 mV full scale.

Date					
Location					
Analyzer					
NO Zero					
NO_2 Zero					
NO_x Zero					
NO Span					
NO_2 Span					
NO_x Span					
Vacuum					
NO Zero VDC					
NO_2 Zero VDC					
NO_x Zero VDC					
NO Span VDC					
NO_2 Span VDC					
NO_x Span VDC					
Converter Eff.					

Remarks:

Figure 6. NO_x analyzer control chart.

8A

FIELD DATA AUDIT SHEET - NO, NO_2, NO_x

STATION: ______________ SAROAD: ______________ DATE: __________

ADDRESS: ______________ START TIME: ________ END TIME: ________

$T_{A\,initial}$ = ________ °C; P_A = ________ MMHG; P_{H_2O} ________ AUDITOR: ______________

$T_{A\,final}$ = ________

ANALYZER/MODEL ______________ S/N ______________ EPA S/N ______________

SPAN SOURCE ______________ CALIBRATION STD. ______________

LAST CALIBRATION DATE ______________ FREQUENCY ______________ RANGE ______________

CALIBRATION COMMENTS ______________

FLOW SETTINGS ______________

ZERO SETTINGS NO ____________ NO_x ____________ NO_2 ____________

SPAN SETTINGS NO ____________ NO_x ____________ NO_2 ____________

OTHER SETTINGS ______________

DAS: ______________ RECORDER: ______________

AUDIT SYSTEM ______________ BUBBLE FLOW METER S/N ______________

AUDIT STANDARD ______________; P = ____________ P.S.I.; [NO] = ____________ PPM

ZERO AIR SUPPLY ______________ $[NO_2]$ = ____________ PPM

FLOW CORRECTION: $\left(\frac{P_A - P_{H_2O}}{760}\right) \times \left(\frac{298K}{T_A = 273°C}\right) = \text{\_\_\_\_\_\_\_\_\_\_} = (C_F)$

DILUTION AIR FLOW: VOLUME ____________ CC FLOW METER R/O ______________

T_1 = ____________

T_2 = ____________ $\bar{T}$ = ____________ $\text{MIN};\left(\frac{\text{VOLUME}}{\bar{T}}\right)(C_F) = \text{\_\_\_\_\_\_\_\_\_\_} \frac{CC}{MIN}$

T_3 = ____________

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Figure 7. Field Data Audit Sheet - NO, NO_2, NO_x Calibration.

OZONE GENERATOR FLOW: VOLUME ____________________ CC FLOW METER R/O _____________

T_1 = ______

T_2 = ______ $\bar{T}$ = ________ MIN. $\left(\frac{\text{VOLUME}}{\bar{T}}\right)\left(C_F\right)$ = _________ $\frac{\text{CC}}{\text{MIN.}}$

T_3 = ______

ZERO AIR RESPONSE

	VDC	% CHART	( )	PPM
NO	______	______	______	______
NO_2	______	______	______	______
NO_x	______	______	______	______

TOTAL DILUTION FLOW: VOLUME ______________ CC/M

AUDIT POINT I
(SLAMS/NAMS 0.400-0.450 PPM)

CRITERIA ________________

POLLUTANT FLOW MEASUREMENT

VOLUME __________ CC

FLOW METER R/O _________________

T_1 = __________

T_2 = __________ $\bar{T}$ = ____________ MIN. $\left(\frac{\text{VOLUME}}{\bar{T}}\right)\left(C_F\right)$ = _______ $\frac{\text{CC}}{\text{MIN}}$

T_3 = __________

NO, NO_x AUDIT CONCENTRATION = _____________ PPM

ANALYZER RESPONSE

	VDC	% CHART	( )	PPM
NO	______	______	______	______
NO_2	______	______	______	______
NO_x	______	______	______	______

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Figure 7. (cont'd.)

TOTAL DILUTION AIR: VOLUME ____________________ CC/M

AUDIT POINT II
(SLAMS/NAMS: 0.150- 0.200 PPM)

CRITERIA ______________

POLLUTANT FLOW MEASUREMENT

VOLUME __________ CC

FLOW METER R/O ________________

T_1 = ______
T_2 = ______
T_3 = ______

$\bar{T}$ = ________ MIN. $\left(\frac{\text{VOLUME}}{\bar{T}}\right)\left(\text{CF}\right)$ = ________ $\frac{\text{CC}}{\text{MIN.}}$

NO, NO_x AUDIT CONCENTRATION = ______________ PPM

ANALYZER RESPONSE

	VDC	% CHART	( )	PPM
NO				
NO_2				
NO_x				

AUDIT POINT III
(SLAMS/NAMS: 0.030-0.080 PPM)

CRITERIA ______________

POLLUTANT FLOW MEASUREMENT

VOLUME __________ CC

FLOW METER R/O ________________

T_1 = __________
T_2 = __________
T_3 = __________

$\bar{T}$ = ____________ MIN. $\left(\frac{\text{VOLUME}}{\bar{T}}\right)\left(\text{CF}\right)$ = ________ $\frac{\text{CC}}{\text{MIN}}$

NO, NO_x AUDIT CONCENTRATION = ______________ PPM

ANALYZER RESPONSE

	VDC	% CHART	( )	PPM
NO				
NO_2				
NO_x				

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Figure 7. (cont'd.)

TOTAL DILUTION AIR: VOLUME ____________________ CC/M

AUDIT POINT IV　　　　CRITERIA ______________

POLLUTANT FLOW MEASUREMENT

VOLUME __________ CC　　　　FLOW METER R/O ______________

T_1 = ______

T_2 = ______

T_3 = ______

$\bar{T}$ = ________ MIN. $\left(\frac{\text{VOLUME}}{\bar{T}}\right)\left(C_F\right)$ = ________ $\frac{\text{CC}}{\text{MIN.}}$

NO, NO_X AUDIT CONCENTRATION = ______________ PPM

ANALYZER RESPONSE

	VDC	% CHART	(　　)	PPM
NO				
NO_2				
NO_X				

AUDIT POINT V　　　　CRITERIA ______________

POLLUTANT FLOW MEASUREMENT

VOLUME __________ CC　　　　FLOW METER R/O ______________

T_1 = __________

T_2 = __________

T_3 = __________

$\bar{T}$ = ____________ MIN. $\left(\frac{\text{VOLUME}}{\bar{T}}\right)\left(C_F\right)$ = ________ $\frac{\text{CC}}{\text{MIN}}$

NO, NO_X AUDIT CONCENTRATION = ______________ PPM

ANALYZER RESPONSE

	VDC	% CHART	(　　)	PPM
NO				
NO_2				
NO_X				

Figure 7. (cont'd.)

ORIGINAL FULL SCALE [NO]

POLLUTANT FLOW MEASUREMENT

VOLUME = ______________ CC

FLOW METER R/O ____________

T_1 = ________

T_2 = ________

T_3 = ________

$\bar{T}$ = ________ MIN. $\left(\frac{\text{VOLUME}}{\bar{T}}\right)$

(CF) = ________ $\frac{\text{CC}}{\text{MIN.}}$

AUDIT RESPONSE

	VDC	% CHART	[ ] ORIG
NO			
NO_X			

NO REGRESSION: (% CHART OR VDC (Y) VS. AUDIT [NO]X)

M = __________

B = __________

R = __________

NO_X REGRESSION

M = ________

B = ________

R = ________

NO_2 AUDIT POINT I

(SLAMS/NAMS 0.350 — 0.450 PPM)

CRITERIA ________________

OZONATOR SLEEVE SETTING = ________________

AUDIT $[NO_2] = [NO]_{ORIG} - [NO]_{REM}$ = ________ PPM

ANALYZER RESPONSE

$[NO, NO_X]_{REM}$		VDC	% CHART	( )	PPM
	NO				
	NO_2				
	NO_X				

% CONVERTER EFFICIENCY = ____________________

$$\frac{[NO_2]_{CURRENT} - ([NO_X]_{ORIG} - [NO_X]_{CURRENT}}{[NO_2]_{CURRENT}} \times 100$$

Figure 7. (cont'd.)

NO_2 AUDIT POINT II CRITERIA ____________________

(SLAMS/NAMS 0.150-0.200 PPM)

OZONATOR SLEEVE SETTING = ________________________

AUDIT $[NO_2] = [NO]_{ORIG} - [NO]_{REM}$ = _________PPM

ANALYZER RESPONSE

$[NO, NO_x]_{REM}$		VDC	% CHART	( )	PPM
____________	NO	__________	__________	__________	__________
	NO_2	__________	__________	__________	__________
____________	NO_x	__________	__________	__________	__________

% CONVERTER EFFICIENCY = ______________________

$$\frac{[NO_2]_{CURRENT} - ([NO_x]_{ORIG} - [NO_x]_{CURRENT}}{[NO_2]_{CURRENT}} \times 100$$

NO_2 AUDIT POINT III CRITERIA ____________________

(SLAMS/NAMS 0.030-0.080 PPM)

OZONATOR SLEEVE SETTING = ________________________

EUDIT $[NO_2] = [NO]_{ORIG} - [NO]_{REM}$ = _________PPM

ANALYZER RESPONSE

$[NO, NO_x]_{REM}$		VDC	% CHART	( )	PPM
____________	NO	__________	__________	__________	__________
	NO_2	__________	__________	__________	__________
____________	NO_x	__________	__________	__________	__________

% CONVERTER EFFICIENCY = ______________________

$$\frac{[NO_2]_{CURRENT} - ([NO_x]_{ORIG} - [NO_x]_{CURRENT}}{[NO_2]_{CURRENT}} \times 100$$

Figure 7. (cont'd.)

NO_2 AUDIT POINT IV

CRITERIA ____________

OZONATOR SLEEVE SETTING = ____________

AUDIT $[NO_2] = [NO]_{ORIG} - [NO]_{REM}$ = ________ PPM

ANALYZER RESPONSE

$[NO,NO_x]_{REM}$		VDC	% CHART	( )	PPM
	NO				
	NO_2				
	NO_x				

% CONVERTER EFFICIENCY = ____________

$$\frac{[NO_2]_{CURRENT} - ([NO_x]_{ORIG} - [NO_x]_{CURRENT})}{[NO_2]_{CURRENT}} \times 100$$

NO_2 AUDIT POINT V

CRITERIA ____________

OZONATOR SLEEVE SETTING = ____________

AUDIT $[NO_2] = [NO]_{ORIG} - [NO]_{REM}$ = ________ PPM

ANALYZER RESPONSE

$[NO,NO_x]_{REM}$		VDC	% CHART	( )	PPM
	NO				
	NO_2				
	NO_x				

% CONVERTER EFFICIENCY = ____________

$$\frac{[NO_2]_{CURRENT} - ([NO_x]_{ORIG} - [NO_x]_{CURRENT})}{[NO_2]_{CURRENT}} \times 100$$

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Figure 7.

Calibration gases, 50 ppm and 10 ppm CO, were received and certified by the QA laboratory. Zero air (Airco 0.1 THC grade) was also certified by the laboratory.

Sample protocol. The protocol data sheet is given in Figure 8.

Air Exchange--

Collection method. Air exchange rates at each sampling location were determined using a tracer gas technique. The tracer gas, SF_6, was released in the building at the air intake system and allowed to equilibrate with the building air. Following equilibration, air samples were collected using sequential syringe samplers (DSI, Model DS1-12).

Air sampling was carried out over 5 time periods. Each period involved a total of 5 syringe samplers collected in 4 locations within the building.

Table 11 shows the collection schedule used for this building. Analytical screening by GC/ECD of the air samples collected subsequent to the first exchange rate measurement showed incomplete dispersion of the tracer to all areas of the building. To compensate for this, SF_6 was released into three air intake ducts to increase the average SF_6 concentration within the building.

Duplicate samples were collected, using separate syringe samplers at three locations in the building.

Preparation of Sampling Materials.

The DSI sequential syringe samplers were inspected and found in good working condition. The sampler was used as specified by the manufacturer.

Sulfur hexafluoride was purchased in a gas cylinder from MG Scientific gases. The gas was checked for purity by GC/ECD analysis. No contaminants were detected.

Preparation of QC Sets. No QC samples were prepared.

Sample Protocol. The protocol data sheet is given in Figure 9.

Primary School

Collection of field samples from the primary school took place in Washington, DC, from May 23 to 26, 1983. Four sampling locations, one outside and three inside, were monitored during that time period. A description of sampling locations is given in Table 12. The number of samples scheduled for collection versus those actually taken are given in Table 13.

FIELD SAMPLING PROTOCOL SHEET - INDOOR AIR STUDY

DATE: ______________________

SAMPLE CODE: ____

AIR SAMPLING

Pump Model: ____________ Serial Number: ____________

Zero (Initial): _________ Span (Initial): ____________

Zero (Final): __________ Span (Final): _____________

Time (Initial): _________

(Final): _________

Temperature (°F): ______________________

Description of Fixed Site Location (include sketch):

GENERAL REMARKS

Figure 8. Sample custody sheet for carbon monoxide.

TABLE 11. PARAMETERS USED IN THE COLLECTION OF AIR SAMPLES FOR AIR EXCHANGE DETERMINATIONS IN THE ELDERLY HOME-1

Collection Cycle	Time Collected	Day Collected[a]	Number of Release Points	Number of Syringes per Sampler	Minutes of Collection Per Syringe	Locations Sampled
1	10:00-12:24	1	1	12	12	2,3,4
2	19:30-23:54	2	2	6	24	2,3
3	10:00-12:12	2	2	6	12	2,3,4,5
4	18:15-20:27	3	3	6	12	2,3,4,5
5	10:00-12:12	3	3	6	12	2,3,4,5

[a] Day 1 began at 18:00 on 3/23/83 and Day 3 ended at 18:00 on 3/26/83.

FIELD SAMPLING PROTOCOL SHEET - INDOOR AIR STUDY

Date: ____________

Sample Code: ____________________

SF_6 Release

Release time, initial: ____________

Release time, final: ____________

Total time (T), (min): ____________

Rotometer reading: ____________

Flow rate (F), (ml/min): ____________

Percent (P) SF_6 in gas: ____________

Volume (V) of SF_6 released: ____________
$(F \times T \times P) \div 100 = V$

Sketch of Location

Sequential Air Sampling (Syringe Type)

Model: ____________________

Serial No.: ____________________

Sample Code	Initial Time (X if not collected)
1	________
2	________
3	________
4	________
5	________
6	________
7	________
8	________
9	________
10	________
11	________
12	________
(ending time)	________

Sketch of Location

Minutes per sample (syringe) ______

No. of samples collected ______

Remarks

Figure 9. Example of a field sampling protocol sheet, air exchange.

TABLE 12. FIELD SAMPLING LOCATIONS FOR THE SCHOOL

Location	Description
1	Ground floor: center section, commons area
2	2nd floor: center section, near stairway
3	4th floor: center section, near stairway
4	Rooftop: center section, near HVAC unit

TABLE 13. SAMPLE COLLECTION AT THE PRIMARY SCHOOL[a]

	Volatile Organic	Pest./PCBs	Formaldehyde	Elements[b]	SF_6[c]
Field Samples (scheduled/collected)	24/23	12/12	12/12	12/8	18/17
Field Duplicates (scheduled/collected)	3/3	2/2	2/2	2/2	2/2
Field Blanks (scheduled/utilized)	4/4	2/2	3/3	8/8[d]	-[e]
Field Control Set (scheduled/utilized)	8/8	2/2	3/3	-	-
Lab Blanks (scheduled/utilized)	6/6	2/2	3/3	-	-
Lab Control Sets (scheduled/utilized)	12/12	2/2	3/3	-	-
Total	57/56	22/22	26/26	22/18	20/19

[a] Does not include QA samples.

[b] Three days of analysis per filter.

[c] Six syringes collected per sampling period.

[d] A blank portion of every filter was analyzed.

[e] Not scheduled.

Generally, methods for sample preparation and collection were identical to those used for the elderly home-1. Only modifications and/or substitutions in these procedure will be discussed.

Inhalable and Respirable Particulates--

Dichotomous samplers. In accordance with the study design, inhalable and respirable particulates were not measured in the primary school with the dichotomous samplers. This parameter had been eliminated from the collection schedule since smoking and other sources of combustion which produce high aerosol levels should not be present in the school.

Piezoelectric monitor. Quasi-real-time measurements of respirable particulates (RSP; $< 3.5\ \mu m$) were made in the school on May 23 and 24 using a piezo-electric monitor (Model 3500, Thermosystems, Inc.) as described previously.

On May 23, measurements were taken at all three indoor sites in the school and at the outdoor site on the roof near the air intake. On May 24, all sites were again measured, this time using two piezobalances running side-by-side and concurrently. An additional site, the school gymnasium, was also visited at the request of several teachers.

On both days, the instrument(s) were cleaned and allowed to equilibrate before sampling began. At least three and up to eight consecutive 2-min readings were taken at each site, both with and without the HEPA filter. Baseline drift of the reference frequency was checked periodically and found to be negligible. When the instruments were moved to the roof, where large changes in humidity and temperature were encountered, the instruments were equilibrated for an additional 15 minutes to improve stability.

Nitrogen Dioxide--

No analyses for NO_2 were performed at the primary school as directed by EPA Project Officer.

Carbon Monoxide --

No analyses for CO were performed at the primary school as directed by the EPA Project Officer.

Air Exchange Rates--

In parallel with sampling air for various pollutants, several air exchange rate determinations were conducted at the elementary school. After release of sulfur hexafluoride (SF_6) into the air intakes of the school, air sampling was conducted during six periods over the 3-day study. Each period involved six syringe samples at 3 or 4 locations within the building. The parameters used in sampling are shown in Table 14. As multiple parallel ventilation zones are used in the building only half (2 of 4 zones) were used in the air exchange determinations. For two exchange rate determinations however, a syringe sampler was left in a ventilation zone adjacent to one spiked with SF_6.

Office Building - Trip 1, July, 1983

Collection of field samples from a new office building in Research Triangle Park took place from Wednesday, July 27 to Friday, July 29, 1983. Six locations were sampled as described in Table 15. The number of samples scheduled for collection vs. those actually taken are given in Table 16.

At the time of sampling, construction was complete and the building had been "finished off" (i.e., wall paper, carpeting, wall partitions, and ceilings were installed); however, numerous moving, cleaning, and other "finishing" activities were still being performed. Pollutant levels during monitoring may have reflected these activities rather than emissions from the new building itself. Because the office building was to be occupied Monday, July 29, it was impossible to select a sampling period which would truly represent a newly constructed, unoccupied building.

Generally, methods for sample preparation and collection were identical to those used for monitoring the elderly home-1. Only modifications and/or substitutions in these procedures will be discussed.

Inhalable and Respirable Particulates--

Inhalable and respirable particulates were scheduled to be collected at three locations in the office building (locations, 1, 2, and 3 - Table 15) and at the outdoor locations. When the dichotomous samplers were set up at the indoor site, it became apparent that these samplers would not be suitable for monitoring occupied offices. First, the sampler is bulky and would occupy too much space in a small office. Second, the pumps are very noisy and there were no remote locations available to place the pumps as a method for reducing noise.

Finally, even if the pumps were placed in remote locations, the partitions between offices were thin and would not effectively reduce noise levels. After consultation with the EPA Project Officer, it was decided to

TABLE 14. PARAMETERS USED IN COLLECTION OF AIR SAMPLES FOR AIR EXCHANGE DETERMINATIONS IN THE PRIMARY SCHOOL

Collection Period	Time Collected	Date Collected	Number of Release Points	Number of Syringes per Sampler	Minutes of Collection per Syringe	Ventilation System Mode	Locations Sampled
1	17:30-19:40	5/23/83	2	6	12	Manual	1,2,3
2	08:45-10:57	5/24/83	2	6	12	Automatic	1,2,3
3[a]	17:30-19:40	5/24/83	2	6	12	Automatic	1,2,3,3a[b]
4[a]	08:45-10:47	5/25/83	2	6	12	Automatic	1,2,3,3a
5	13:00-15:12	5/25/83	2	6	12	Automatic	1,2,3
6	08:45-10:57	5/26/82	2	6	12	Automatic	2,3

[a] Periods in which exchange rates were determined for an adjacent zone to the one being spiked with SF_6.

[b] 4th floor, zone 2, this was not a sampling site for other parameters.

TABLE 15. FIELD SAMPLING LOCATIONS WITHIN THE OFFICE BUILDING

Location	Description		
	Trip 1, Aug. 1983	Trip 2, Sept. 1983	Trip 3, Dec. 1983
1	First floor exterior office	First floor interior office - smoker[a] First floor interior office - nonsmoker[b]	First floor interior office - nonsmoker
2	First floor secretarial office	First floor secretarial area	First floor secretarial area
3	Second floor office	Second floor office - unoccupied	Second floor office - occupied[c]
4	Second floor secretarial area	Second floor secretarial area	Second floor secretarial area
5	Third floor copier room	Third floor copier room	Third floor copier room
6	Outside, at air intake	Outside, at air intake	Outside, at air intake

[a] Monitored from September 6, 1983, 8:00 p.m. to September 7, 10:00 a.m.

[b] Monitored from Septamber 7, 10:00 a.m. to September 8, 10:00 p.m.

[c] Occupant was on vacation. Individual was two offices away from office sampling during Trip 2.

TABLE 16. STATUS OF COLLECTION AND ANALYSIS OF INDOOR AIR STUDY SAMPLES - OFFICE (TRIP 1 - AUG. 1983)

	Volatile Organic	Pest./PCBs	Elements	Formaldehyde	Inhalable Particulate	SF_6[a]
Field Samples (scheduled/collected)[b]	24/24	12/12	12/12	12/12	8/6	16/12
Field Duplicates (scheduled/collected)	3/3	2/3	2/2	2/2	2/1	2/0
Field Blanks (scheduled/utilized)	4/4	4/4	4/4	4/4	4/4	-[c]
Field Control Sets (scheduled/utilized)	4/4	4/4	-	4/4	-	-
Lab Blanks (scheduled/utilized)	2/2	2/2	2/2	2/2	4/4	-
Lab Control Sets (scheduled/utilized)	2/2	2/2	-	2/2	-	-
Total	39/39	26/27	20/20	26/26	18/15	18/12

[a] Six syringes collected per sampling period.

[b] Does not include QA samples.

[c] Not scheduled.

monitor only two indoor and one outdoor locations with the dichotomous samplers during the initial visit. During the follow-up visit, a small battery operated sampler would be used in lieu of the dichotomous samplers.

The piezoelectric monitors utilized at the elderly home-1 and the primary school were not used for testing in this facility.

Elements--

Following the second field effort (primary school), a decision was made, with the concurrence of the EPA Project Officer, to sample and analyze for elements using a different procedure than was used for the first two field trips. The original approach employed a device ("streaker") that provided hourly levels of ca. 22 different elements for both inhalable and noninhalable particulates. The pumps used to collect these samples were exceedingly noisy, and required remote locations for sampling indoor air. This factor, coupled with the high expense associated with the analysis of samples for hourly element levels, led to the decision to use a procedure that was much less costly, provided integrated air element levels, and had been field proven by Florida State University to the same extent as the "streaker" procedure. This new method involved collecting the samples on air particulate aerosol grade (0.3 m m) filters at a sampling rate of 1 L/min. Samples were collected over a 24 h period to provide a ~1.5 m^3 sample size. The entire filter was analyzed, using PIXE techniques, at a fraction of the cost of "streaker" analysis. The air was sampled using portable monitors which were compatible with indoor use in even the quietest environment.

Nitrogen Dioxide--

A decision was made by the EPA Project Officer not to measure NO_2 at the office building.

Carbon Monoxide--

No analyses for CO were performed at the office building as directed by the EPA Project Officer.

Air Exchange Rates--

In parallel with sampling air for various pollutants, several air exchange rate determinations were conducted at the office building. After release of SF_6 into the air intake, sample collection was carried out over three sampling periods at four locations within the building. Sampling locations included one on the first floor, two on the second floor, and one on the third floor.

Design of the air circulation system provided adequate distribution of SF_6 using only one release point. Release and collection of SF_6 was made during the second, third, and fourth sampling periods. Release and collection during the first period was not possible due to the circulation system being turned-off overnight for maintenance.

Office Building - Trip 2, September, 1983

The second sampling trip to the new office building in Research Triangle Park took place from Tuesday, September 6 to Thursday, September 8, 1983. Six locations were sampled as described in Table 15. Sampling locations for the first trip are also included in this Table. As indicated, all of the locations, except Location 1, were identical for the first and second trip. Although it was intended to use all of the same sampling locations, it was not possible to obtain access to the office originally designated as Location 1. As a replacement, another office occupied by a smoker was selected. Prior to beginning monitoring, the occupant was shown the sampling equipment in operation and agreed to allow sampling over the two-day period. However, this office was only monitored from 8:00 p.m., September 6, to 10:00 a.m., September 7, at which time the equipment was moved to an unoccupied office on the same corridor after the occupant had complained that the equipment was too noisy.

The number of samples scheduled for collection versus those actually taken are given in Table 17.

All monitoring procedures for this trip were identical to those used during the first trip to the office building except small portable ambient particulate samplers developed and tested by the National Bureau of Standards were used in lieu of the dichotomous samplers for collecting inhalable and respirable particulates. These NBS samplers are small, battery operated units capable of drawing air, via an impactor stage, through a set of filters at a rate of ~5 L/min. Samples were collected over a 24 h period for a total sample volume of ~ 7.2 m^3. Nucleopore filters (8 μm) were used as the coarse filters for inhalable particulates and 3 μm Teflon filters were the fine filters for respirable particulates. Figure 10 shows a schematic diagram of the NBS sampler including filters.

TABLE 17. STATUS OF COLLECTION AND ANALYSIS OF INDOOR AIR STUDY SAMPLES - OFFICE (TRIP 2 - SEPT. 1983)

	Number of Samples					
	Volatile Organic	Pest./PCBs	Elements	Formaldehyde	Inhalable Particulate	SF_6[a]
Field Samples (scheduled/collected)[b]	24/22	12/12	12/10	12/12	8/6	16/14
Field Duplicates (scheduled/collected)	3/3	2/2	2/2	2/2	2/1	2/2
Field Blanks (scheduled/utilized)	4/4	3/3	3/3	3/3	3/3	-[c]
Field Control Sets (scheduled/utilized)	4/4	3/3	-	3/3	-	-
Lab Blanks (scheduled/utilized)	4/4	2/2	2/2	2/2	2/2	-
Lab Control Sets (scheduled/utilized)	2/2	2/2	-	2/2	-	-
Total	41/39	24/24	19/17	24/24	15/12	18/16

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[a] Six syringes collected per sampling period.

[b] Does not include QA samples.

[c] Not scheduled.

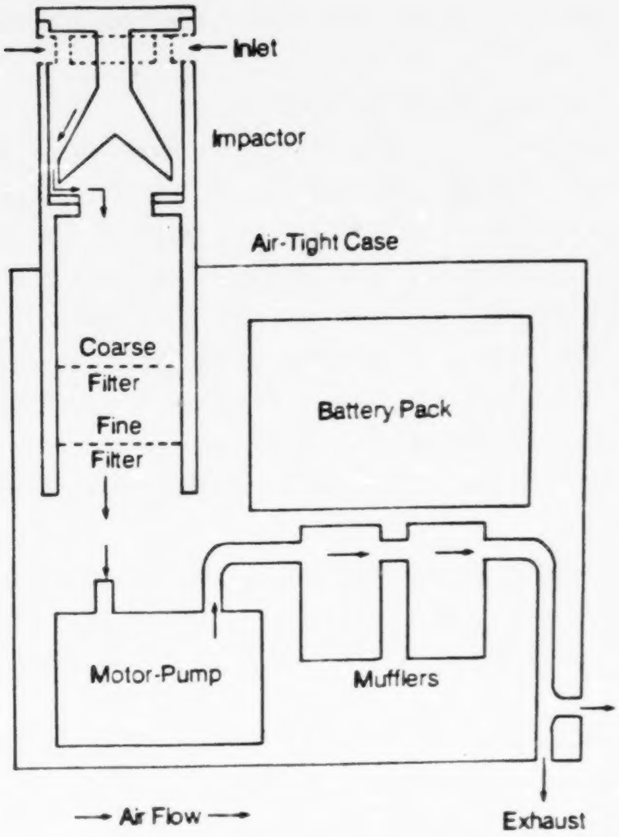
Inlet
Impactor
Air-Tight Case
Coarse
Filter
Fine
Filter
Battery Pack
Motor-Pump
Mufflers
Air Flow
Exhaust

Figure 10. Schematic diagram of the NBS sampler.

Prior to field sampling, it was discovered that the rechargable nickel-cadmium batteries used to power the NBS sampler failed to provide an adequate constant flow over time. The problem was circumvented by replacing the batteries with a variable AC/DC converter power supply which provided a constant DC voltage equivalent to that obtained by the nickel-cadmium batteries.

Office Building - Trip 3, December, 1983

The third sampling trip to the new office building in Research Triangle Park took place from Monday, December 20 to Wednesday, December 22, 1983. Six locations were sampled as described in Table 15. As indicated, all of the locations, except number 3, were identical to the second trip. Although it was intended to use all of the same sampling locations, access could not be obtained to the office originally designated as number 3. As a replacement, another exterior office on the same corridor was selected. The occupant was on vacation during the sampling period and it was felt that there should be very little difference between this office and the office sampled during trip 2.

The number of samples scheduled for collection and those actually taken are given in Table 18. All monitoring procedures for this trip were identical to those used during the second trip to the office building.

Elderly Home-2

A sampling trip at a second elderly home in Washington, DC, took place from Monday, January 9 to Thursday, January 12, 1984. Five locations were sampled as described in Table 19.

A listing of the samples scheduled for collection versus those actually collected is given in Table 20. All monitoring procedures for this trip were identical to those used during the second and third trips to the office building with the exceptions described below.

Inhalable and Respirable Particulates--

On January 9, 1984 the piezobalance instrument used at the first home for the elderly was again used to measure respirable particulates. Again the HEPA filter was employed to correct for combined zero drift and gas-to-particle conversion. The dining room was monitored for one hour (10:40-11:50 AM) to determine concentrations in a common room with few occupants, no smokers, and minimum activity.

TABLE 18. SAMPLE COLLECTION AT THE OFFICE BUILDING (TRIP 3 - DEC. 1983)

	Number of Samples					
	Volatile Organic	Pest./PCBs	Elements	Formaldehyde	Inhalable Particulate	SF_6^a
Field Samples (scheduled/collected)[b]	24/24	12/11	12/11	12/12	8/7	16/14
Field Duplicates (scheduled/collected)	2/2	2/2	2/1	2/2	2/0	2/1
Field Blanks (scheduled/utilized)	4/7	3/4	3/3	3/3	3/3	-[c]
Field Control Sets (scheduled/utilized)	4/7	3/4	-	3/3	-	-
Lab Blanks (scheduled/utilized)	4/5	2/2	2/2	2/2	2/2	-
Lab Control Sets (scheduled/utilized)	2/2	2/2	-	2/2	-	-
Total	40/47	24/25	19/17	24/24	15/12	18/15

[a] Six syringes collected per sampling period.

[b] Does not include QA samples.

[c] Not scheduled.

TABLE 19. FIELD SAMPLING LOCATIONS WITHIN THE ELDERLY HOME-2

Location Number	Description
1	First floor common area-lunchroom, lobby
2	Third floor occupied apartment - nonsmoker
3	Fifth floor unoccupied apartment
4	Eighth floor occupied apartment - smoker
5	Outside on the roof

TABLE 20. SAMPLE COLLECTION - ELDERLY HOME-2

	Number of Samples					
	Volatile Organic	Pest./PCBs	Elements	Formaldehyde	Inhalable Particulate	SF_6[a]
Field Samples (scheduled/collected)[b]	30/30	15/15	15/15	15/15	15/13	24/24
Field Duplicates (scheduled/collected)	3/2	2/2	2/1	2/2	1/1	2/2
Field Blanks (scheduled/utilized)	4/4	3/3	3/3	5/5	3/3	-[c]
Field Control Sets (scheduled/utilized)	4/4	3/3	-	5/5	-	-
Lab Blanks (scheduled/utilized)	2/2	2/2	2/2	4/4	2/2	-
Lab Controls (scheduled/utilized)	2/2	2/2	-	4/4	-	-
Total	45/44	27/27	22/21	35/35	21/19	26/26

[a] Six syringes collected per sampling period.

[b] Does not include QA samples.

[c] Not scheduled.

Two GCA Miniram instruments were tested side by side with the Piezobalance under a variety of conditions. The first test took place over a 10 minute period in an unoccupied first floor staff meeting room (10'x16'). The second test took place in the dining room during lunch (12:30-1:30 PM). A final test was performed in the dining room between 2:00 and 2:25 PM.

At 3:00 PM on Tuesday, January 10, 1984, the two Minirams were deployed in the 8th floor smoker's apartment and the 4th floor nonsmoker's apartment.

The continuous measurement feature, by which consecutive 8 hour and 20 minute averages are taken, was not operating on one Miniram. The instrument was started manually each time sampling was performed in the nonsmoker's apartment. This Miniram took readings for the first 8 hours and 20 minutes of each 12-h period, but was off for the final 4 h. Thus, six consecutive 8 h periods were monitored in the smoker's apartment, but only four staggered 8 h periods were monitored in the nonsmoker's apartment.

Air Exchange--

Air samples were collected throughout the monitoring period for determining air exchange rates in the second elderly home. Sample collection was carried out over six sampling periods at the four indoor locations. Several problems were encountered with the release of SF_6. First, the air exchange rates at each sampling location were independently controlled making a predicatable release of SF_6 impossible. Second, a single air intake did not serve the sampling locations and SF_6 had to be released directly into each room.

SECTION 5

BUILDING SURVEY

OVERVIEW

Data Collection

The collection of data on building characteristics and activities involved several tasks. These included preliminary meetings with RTI and EPA project staff to determine the data to be collected. Once this determination had been made, drafts of the various documents were developed and circulated for review. After the comments were returned and compiled, a second draft was prepared and the review process repeated. Based on the final review, the four final data collection documents were prepared. These forms are more completely described in subsequent paragraphs. The next phase of the data collection activity was the identification of the appropriate personnel to be interviewed at the monitoring sites. If personnel were identified prior to the site visit, initial telephone contacts were made to identify the types of data to be collected. These calls were supplemented by contacts from the EPA project staff, facilitating data acquisition. Once the project team arrived on site, data collection began with the final identification of the monitoring locations. This selection was in some cases influenced by data reviewed, and interviews conducted during the first hours on site. Once the sites were selected, equipment was placed, and the formal interview process begun. With one exception, as noted below, all forms were completed at the beginning of the study period for the particular site. The remaining form captured data on an ongoing basis, and was thus completed during the start and finish of each individual monitoring period. The remaining sections of this chapter describe the data collection instruments and the data collected using them, for each of the four sites visited as part of this effort.

Data Collection Instruments

Using the iterative review process described previously, four data collection instruments were developed. These forms collected different data, using various sources, and were completed at various times throughout the monitoring period. The four forms included the General Area Description, the Building Questionnaire, the Monitor Location Questionnaire, and the General Interview Information form. Each is described in more detail in the following paragraphs. Copies of these forms are given in Appendix A.

General Area Description--

The purpose of this form was to capture general data on the area surrounding the site being monitored. The area of interest was an elliptical area of approximately one-half mile radius, with an additional half mile upwind inclusion. Data descriptive of the area included amounts of open land, water, hills and other impediments to wind flow, and descriptions of the surrounding structures or land on each side of the building. These surrounding areas were described in terms of potential effects on the monitoring site, and included data on sources of chemicals, traffic volume, and any unusual occurrences in the immediate past few days. This form was completed once, at the beginning of the study period for the particular site.

Building Questionnaire--

This document, also completed once at the beginning of the study period, was used to capture data describing the structure containing the individual monitoring locations. The document contains five sections, each with a differing focus. The first section describes the general characteristics of the structure, focusing on usage, age and recent renovations, size and volume, building materials, attached garages, and water supply. The second section describes the interior of the structure in terms of internal construction characteristics and materials, the heating, ventilation, and air conditioning systems, including the normal climate maintained. The third section focuses on building modifications, especially those affecting building tightness. The fourth section captured data on internal maintenance and decor by describing the internal furnishings, use of pesticides and cleaning products. The types of products, and the frequency of application were detailed. The final section describes any external influences, such as pressure gradients, unusual local events, and any known outdoor air quality information. In addition, data on local meteorology, both micro and macro, were recorded in this section.

Monitor Location Questionnaire--

This form collected information about the specific locations where monitoring devices were placed, and was completed daily for each day that monitoring was undertaken. Repeated visits to a site generated repeated completions of this form; some parts of the Building Questionnaire were also repeated to capture data on any major structural improvements or significant modifications which might influence the indoor air quality. The Monitor Location Questionnaire starts with a general description of the location of the monitors, focusing on the use of the area, as well as its size, ventilation, insulation, and the presence of products which might affect air quality through the direct introduction of a chemical, or through the outgassing of various products as the materials age. Products of particular interest included foam insulation, polyurethane, plywood, plastics, carpeting, wall coverings, and pesticides. Data were also collected on the presence and use of gas cooking stoves, gas or kerosene space heaters, free standing stoves or fireplaces, clothes dryers, and humidifiers. Information on the filters or particle scavengers used, and vacuuming and dusting regimens was collected and supplemented with data on the amounts and frequency of use of household products, including cleaning supplies, aerosol products, and housekeeping products. The final section of this form collected various data and was specific to the period being monitored. These data include the dates and times of monitoring, the inside and outside meteorology (temperature, humidity, wind speed and direction, and barometric pressure). Additional data on occupancy levels, smoking status, and the presence of pets or pest strips were collected, as was an indication of the presence of open windows. Specific descriptions of any unusual products in use in the immediate area were made, as was a recording of the details of any unusual occurrence during the monitoring period.

This form collected information about the data collection process. It identified the persons from whom data were collected, and recorded addresses and phone numbers in case recontact became necessary. The form also provided a final place in which to record any unusual circumstances which occurred that might have any affect on the data collected and its subsequent analysis.

RESULTS

Three of the buildings were monitored for one three day period, while the fourth building was monitored three times in an attempt to discover temporal relationships within the data collected. The remainder of this section describes each of the sites visited, including specific information about the site in general, the building monitored, and the specific locations of the monitoring instrumentation. The data presented are a summarization of the data collected on the various instruments described previously.

Elderly Home-1

During the period of March 23 to March 26, 1983, an elderly home in the Washington, D.C. area was monitored. The data were collected by direct observation and measurement, and through discussions with the assistant administrator and the maintenance engineer of the building. Both individuals were extremely knowledgeable and helpful. Additional data were obtained by telephone calls to the pesticide applicators retained by the owners of the facility. During the time of the monitoring, only one unusual occurrence was noted and reported. On the first evening that the monitoring team was on-site, a pot of soup was burned on a stove in a second floor apartment. An odor was apparent in a wide area around the apartment, and an attempt was made by the resident to mask the odor with an unidentified aerosol spray.

General Area Description--

The building was a multi-story structure housing an elderly home in the Northwest section of Washington, D.C. It was located in a primarily residential area, with housing on three sides, and a light commercial area located two blocks to the south. The site was located on the slope of a hill, rising gently from west to east. There was a small percentage of open area around the building, and no structures that would impede wind flow. There were no observed sources of chemicals, other than two nearby parking lots. The site was located several blocks from the nearest main artery, and was surrounded by low traffic volume city streets.

Building Description--

The building was a five story, "L-shaped" building located in a residential area. The building construction was started in 1969, with first occupancy in 1970. The building was constructed with a brick and glass exterior, and contained over 25,000 square feet, with normal ceiling heights of seven and one-half feet, with two exceptions totaling 1900 square feet under ten-foot ceilings. The building had no garage, and was provided with normal city utilities, including water. Internal construction included poured concrete floors covered with carpet or quarry tile, plaster board or plaster walls, and spray stucco ceilings on the false ceilings containing the interfloor spacing. Heating was provided by forced hot air using a gas fired boiler to create steam. Supplemental heat was provided in all bathrooms through the use of heat lamps. The hot water supply was from the heating system boiler. The main kitchen facility used gas for cooking, while individuals used electric appliances in their apartments. Air conditioning was provided using the same ducts as the heating system to circulate air cooled using an evaporative cooling system located on the roof. The cooler system pipes contained chemicals to retard corrosion or other contamination. Air exhaust was handled through individual vents in each bathroom, and through larger ports located at the fifth floor lounge, the kitchen, and the dining room. Additional ventilation could be provided through over 200 windows in the facility, all of which contained some sections which could be opened. Other penetration of the structure included fifteen doors, an overhead door in the shop area, four main air inlets and exhausts, as well as fifty bathroom exhausts to the roof, and sixteen common area exhausts. Temperature was maintained at 72°F year round, and the humidity was not controlled.

At the time of this monitoring, several new internal decor purchases had been made. These included 850 square feet of lined, synthetic polyester drapes, 5985 square feet of synthetic carpet in the dining area and some apartments, 10,000 square feet of new paint in several apartments, and 300 square feet of new plastering. Pesticide treatment occurred twice a month in all common areas, and as needed in the individual apartments. The last treatments were nine days prior to the start of monitoring. The products used contained Resmethrin in an aerosol preparation. Cleaning products used on a daily basis included Windex window cleaner, Behold spray wax, an aerosol cleaner, and a quatenary cleaning liquid disinfectant.

Monitoring Locations--

Six individual locations were selected for monitoring and are described in the following paragraphs. The general description of each location is followed by any changes observed over the three day monitoring period. The first location was the roof of the building, at the air intake on the west end of the building. The location was approximately 60 feet above the roadway, and was situated on the south side of the west end of the structure, just outside a six square foot louvered air intake. Temperature, humidity, and other environmental variables reflected the ambient conditions at the time of monitoring.

The second location was a fifth floor lounge used as a meeting and music room. The room contained 1110 square feet in a rectangular shape with a cutout of 105 square feet. The small cutout area was divided in half, one side containing mechanical equipment, the other containing a small kitchen. The kitchen contained a refrigerator, sink, table and several chairs. The ceiling height was 10 feet. The area contained both forced air inlets and passive exhaust vents, as well as a full outside wall of windows. The room contained two couches, two wing-backed chairs, 75 straight-back chairs, seven tables, a piano, an organ, a television, and a speaker's lectern. Most of the furnishings were as old as the building, but a few, the piano and lectern, were only six to seven years old. The wallpaper, carpets, and some drapes were the same age as the building, while one set of drapes, 100 yards, were eight months of age. The occupancy of the location during the monitoring period was light, averaging four. No smoking was observed, and no known sources of chemicals were observed or reported, other than the routine pesticide application already noted.

The third location was the third floor lounge and piano room. The room was rectangle of 540 square feet with a seven and one-half foot ceiling height. The room contained two wall mounted heating and air conditioning units. A wide assortment of furnishings were found in the room, including seven stuffed chairs, seven straight back chairs, seven tables, a piano, and a lecturn. With the exception of the straight-back chairs and the piano, all the other furniture was thirteen years old. The vinyl wallpaper and the cut-pile synthetic carpeting were also thirteen years of age. Occupancy of the room varied greatly, averaging at least ten in the daytime and thirteen at night. During one monitoring period, about fifty percent of the occupants were smokers. Other than the pesticide application described previously, no sources of chemicals were observed or described.

One wall contained two large sliding glass doors which opened onto an exterior patio. The door remained closed during the sampling periods.

The fourth location monitored was a common dining area located on the main level of the building. The area was 990 square feet under a ten foot ceiling. Air movement was related to five inlets located on the walls and eight returns in the ceiling, and was supplemented by natural leakage through one side wall made of windows and glass doors. The room contained 28 tables, a piano and 96 chairs. The chairs had seat cushions with polyurethane foam. Drapes and wallpaper had been replaced three and one-half years before, while the polyester carpeting was only six months old. Occupancy of the room was ninety-six persons during the dinner hour, and only occasional other use. No smoking was observed, and other than the normal pesticide usage and the daily use of an all purpose cleaner, no other sources of chemicals were observed or reported.

The fifth location was a studio style apartment on the fourth floor, occupied by one person. The unit contained 378 square feet under a seven and one-half foot ceiling. Ventilation, heating and cooling were provided through a single unit bringing in outside air through a filter. The air temperature was modified by passing it across pipes from the central system, containing hot or cold water. The apartment contained the occupant's own furnishings of variable age, including a breakfront, a desk, a credenza, two bookcases, two small tables, two stuffed chairs, four wooden chairs, and a single bed. The carpeting was approximately one year old and was a synthetic, cut-pile carpet with a latex backing, glued to the floor. The unit was occupied by one person, who did not smoke. No sources of chemicals were observed other than the normal pesticide application, and some household cleaning products.

The sixth location was also a studio apartment occupied by one individual. This unit was located on the ground level, at one end of the building. It also contained 378 square feet under seven and one-half foot ceilings. The ventilation in this apartment was identical to all others, as previously described. The apartment contained the belongings of the occupant, and included a bed on a frame, five wooden frame chairs, one desk, a wooden table, a wooden cabinet, a wooden dresser, and one stuffed chair. All furnishings were at least ten years of age. There were no wall coverings and the carpet was the original, thirteen year old, cut-pile synthetic. The single occupant was in the apartment most of the time, and was a moderate smoker, smoking approximately five cigarettes per day. Other than the pesticide usage reported previously, and a single "stick-up deodorant" no sources of chemicals were observed or reported.

All monitoring locations in this building remained relatively constant over the course of the observations. Some variation in the number of persons present at any time was expected and observed, yet the activities remained constant.

Primary School

During the period of May 23 to May 26, 1983, a Public School in the Washington, D.C., area was monitored. The data were collected through direct observation and measurement, and through discussions with the maintenance engineer for the building, and with other staff of the facility. All parties were knowledgeable and helpful. Additional assistance was provided by the maintenance department of the D.C. school system. No unusual occurrences were observed or reported during the monitoring period.

The building did not lend itself to the collection of the types of data necessary for this study for two main reasons. First, the building was of an open design with no internal walls, other than some structural supports. This did not permit the clear definition of areas for the contribution of influences of the internal fittings of the building. Second, the building used vertical HVAC zones, which when combined with the lack of internal boundaries, allowed for increased air mixing, with subsequent difficulty in determining air flows and diffusion.

General Area Description--

This building was a multi-story structure occupying one city block in the middle of a residential area in Northeast Washington, D.C. It was surrounded by mainly single family housing, with a few apartment houses located nearby. There was minimal open area around the site, with the exception of the playgrounds of the school. The surrounding streets had minimal traffic flow, with two exceptions. The street in front of the school carried more traffic at the beginning and end of the school day, and there was a major thoroughfare located two blocks south of the school. No sources of chemicals or other pollutants were observed or reported.

Building Description--

At the time of this monitoring the building was eight years old, and no additions or renovations had been made to the structure. The building contained 94,000 square feet with an average ceiling height of 15 feet. However, there was an area of 6,400 square feet under a ceiling twenty feet high. The building had an exterior construction of poured concrete and glass. It had no garage area, and was supplied with standard municpal utilities, including city water.

The interior construction consisted of poured concrete floors covered with carpet, concrete or cinder block walls, and poured concrete ceiling covered with ceiling tiles. The walls in the building were for structural support only, with areas divided only by the use of portable wall units and blackboards. Hallway areas had dropped ceilings for the routing of mechanical equipment.

Electricity was used to create hot air for heating, and was used for cooking and hot water. Air conditioning was provided with forced air and condenser coils. Multiple roof units served the various ventilation zones in the building. Filters were provided at each of the air handling units. Natural leakage was supplemented by special exhausts for the bathrooms and kitchen areas. There were no windows in the facility which could be opened, and of 38 doors, only 10 were used regularly. There were multiple openings through the floors, due to the open design of the building. The temperature was maintained at 72^{o}F in the winter and at 68^{o}F during the summer.

Over the six months prior to monitoring, minimal changes were made in the physical structure. Two 4 x 10 foot patches of the roof were retarred, and approximately five percent of the walls were repainted with an enamel paint, and approximately eighty ceiling tiles were replaced. The structure is treated with pesticides on a monthly basis, the last time being eleven days prior to the start of monitoring. A one percent solution of Diazinon in water is applied with an air pump spray can. Cleaning products used on a regular basis include Exclusive Carpet Shampoo, BK-LFI disinfectant, and a detergent soap, the last two being used or replenished daily.

Monitoring Locations--

Monitoring equipment was located in four locations at the building. The first location was an all-purpose meeting area on the ground floor. The area of this location within the ventilation zone was estimated to be 3200 square feet, under a twenty foot ceiling. Ventilation of this area was shared with one other section of the zone, and was supplied by one unit located on the roof. This unit provided forced air for heating, cooling, or ventilation only.

The area contained a wood stage, five sets of tables and benches, 200 metal chairs, and a piano. All furnishings were the age of the building, eight years old. Occupancy of this area was variable with the usage. No smoking was observed, nor were any sources of chemicals observed or reported. This area was immediately adjacent to the central stairway.

The second and third locations were identical open classroom spaces on the second and fourth floors of the building. Both locations contained 3200 square feet under ten foot ceilings, and shared air handling facilities. Both locations contained built-in cabinets along one structural wall, twenty to thirty desks and chairs, and miscellaneous portable walls and blackboards. All the areas were open to the rest of the facility, with a great deal of difficulty involved in delineating the area of interest. No smoking was observed in the areas, nor were there any sources of chemicals observed or reported.

The fourth location was on the roof, approximately fifty feet above the nearest roadway. The monitoring equipment was located near the air handling units serving the internal areas being monitored. The location was somewhat sheltered by the low parapet wall around the roof, but was subject to the ambient conditions of temperature, humidity, wind, and barometric pressure.

Elderly Home-2

During the period of January 9 to January 12, 1984, a second elderly home in the Washington, D.C. area was monitored. Once again, data were collected through direct observation and measurement, and through discussions with the Chief Engineer of the building. Additional information was obtained during discussion with other staff at the facility. This facility presented one difficulty in that the central air handling units for the facility served primarily the common areas of the building, a relatively small percentage of the structure. This confounded the ability to measure air flow and diffusion in the structure.

General Area Description--

The structure being monitored was a multi-story residential facility in Washington, D.C., surrounded on 3 sides by other multi-story buildings. There was minimal open area in the total urban area surrounding the site. Wind flow was broken by the tall structures on all sides. The site was located approximately one-half block from the George Washington University Medical School. The site was separated by only an open parking area from the Medical School. The site was surrounded by heavily trafficked city streets, with one major thoroughfare located one block away. No unusual occurrences were reported just prior to or during the monitoring period, and no sources of chemicals were observed in the immediate vicinity.

Building Description--

The building being monitored was a five year old, nine-story residential facility of brick and glass exterior construction, with no renovations or additions having been made since construction. The structure contained over 78,000 square feet of usable space, under eight foot ceilings. The only exception was the first floor, which contained 10,000 square feet under a nine foot ceiling. The building did not have an attached garage, but did have some parking spots adjacent to the structure. The building was serviced by municipal utilities, including city water.

The interior construction consisted of concrete floors covered with carpeting walls completed with dry wall finish, and ceilings finished with acoustical tiles. Heating was provided by forced air over pipes containing water heated in a boiler fired with #2 heating oil. This was also the source of domestic hot water. Air conditioning was provided by forced air over water cooled by an electric powered compressor and cooling unit. This heating and cooling was for the common areas of the building. Climate control in the individual apartments was maintained through individual wall mounted heater/air conditioners. The bathrooms and kitchen areas of each apartment received some central air, and contain exhaust vents to the central system. Some additional ventilation may be achieved through the 189 windows present in the structure. Usage of these windows was estimated at 70 percent. The building had eight doors and two elevator shafts and two stairwells to permit additional air circulation. Temperature was maintained at 75°F and the humidity was maintained at 50 percent. There were filters in all air handling units. Filters in the main units were changed monthly, while the filters in each apartment were changed twice a year.

There had been no reported modifications or renovations to the exterior within the past six months, nor were any weatherization actions taken in the same period. Changes in interior decor included new furniture in the lobby, comprised of four chairs, one couch, and two tables; 3000 square feet of new synthetic carpet, 300 square feet of new wallpaper, and 3600 square feet of new interior paint. Common areas of the building were treated with pesticides on a weekly basis, with the latest treatment on the morning that monitoring began. Treatment was done with an aerosol spray of one percent solution of Resmethrin, manufactured by Whitmire Research Labs, St. Louis, MO. Various cleaning products were used on a daily basis, and included Pine Oil disinfectant, stainless steel polish, an all-purpose cleaner, Comet Cleanser, and Windex. No other sources of chemicals were observed or reported.

Monitoring Locations--

Monitoring was carried out at five locations in this site. The first location was the main dining area on the first floor of the building. The dining area measured 1800 square feet under a nine foot ceiling, and was situated three feet below the nearest roadway surface. Ventilation in the area was from the common air handling units, with mixing provided by three ceiling fans. The outside wall of this area was glass, with few windows. Furniture in the area consisted of 48 wood and upholstery chairs, and thirteen wood tables. The carpeting in the area was five years old, and was vacuumed daily. Occupancy of the area varied, with peaks at meal time, and occasional usage at other times. The main area was designated as a nonsmoking area.

The second location was the fourth floor apartment of a nonsmoker. The apartment measured 270 square feet under an eight foot ceiling, and was located approximately forty feet above the nearest roadway. Furnishings in the apartment included a wooden bureau, two sofas, two wood tables, two chairs, and a TV on a cart. The walls were painted dry-wall, and the carpet was five years old. Raid pesticide and an oil-based dust product were reported to be used weekly. No other chemical sources were observed or reported.

The third location was a vacant apartment on the fifth floor. It measured 200 square feet under an eight foot ceiling, and was located 45 feet above the roadway on the side of the building. The only furnishing in the apartment were kitchen appliances such as a range and refrigerator. The apartment contained the same five year old carpeting as noted elsewhere. During the last twelve hour sampling period the apartment was cleaned in preparation for occupancy. There was a container of Ajax present and the distinct odor of Lysol throughout the apartment. An application of pesticides may have also occurred during that period.

The fourth location was the eighth floor apartment of a person who was a smoker. It contained 320 square feet under an eight foot ceiling, and was located eighty feet above the nearest roadway. The resident's furniture included two plastic side chairs, two wooden desks, a sofa, a bookstand, three wood tables, and three wood chairs. The wall treatment consisted of paint over the dry wall, and the carpet was the five year old material found elsewhere in the building. The only observed source of chemicals in the immediate vicinity was a neighbor painting his apartment and acrylic paint which the resident used for a hobby.

The fifth location was on the roof of the building. The location was approximately ninety feet above the roadway and was protected on one side by the penthouse structure containing the mechanical equipment. The location was fully exposed to the ambient meteorological conditions. No sources of chemical exposure were observed or reported.

Office Building

The final site to be discussed is a multi-story commercial office building located in the primarily rural Research Triangle Park area of central North Carolina. The site was visited on three separate occasions for three days each. Monitoring was undertaken in multiple internal and external locations, and the data examined for the existence of temporal variation in the levels of chemicals observed. The first visit was made during the time period of July 27 to July 29, 1983. This period was just prior to the building being occupied by the single tenant for which it was constructed. The second visit was during the period immediately after occupancy of the building, from September 6 to September 8, 1983. The final visit was conducted from December 19 to December 21, 1984. General information about the building and the site on which it is located was obtained during the first visit and only changes were noted during the subsequent visits. Some variation in the exact location of the monitoring locations was necessary due to changes in office occupancy over time; all changes will be discussed in the appropriate sections. Initial information was gathered with the assistance of the developer of the building as well as the manager, and various tradesmen and craftsmen involved in the completion and maintenance of the facility. Excellent cooperation was obtained from all persons involved.

General Area Description--

The site was an office building set in a wooded rural area of central North Carolina. The only major road in the area was an Interstate extension which is approximately one-half mile to the east through moderately dense woods. The other roads in the vicinity were local access roads with low traffic densities except at the beginning and end of the work day. There were no known sources of chemicals in the adjacent areas, but some final construction and landscaping activities may have had an influence on the results. At least one time during monitoring, an oil mixture was sprayed on hay placed over fresh ground cover.

Building Description--

The building was a newly-constructed, three story, poured concrete and glass office building. The building contained 55,000 square feet of usable space, most of which was under nine foot ceilings, with two foot dead space between floors containing the common plenum for air return. A 1440 square foot lobby had a ceiling height of twenty feet. There was no parking structure near the building; employee parking was in an adjacent lot. The building was served by commercial utilities, including the local city/county water supply. The building was constructed with movable walls, as well as false ceilings. The walls were vinyl covering over wall board on both the fixed and movable walls. The floors were poured concrete covered with carpet, and the ceilings were finished with acoustical tile.

Heating was a combination of passive solar, natural heat production, and supplemental forced hot air. Air was heated when passed over pipes of water heated in a gas-fired boiler. Cooling was provided using the same duct work to carry air cooled by an electrically powered water cooler and compressor. Air return was a passive system using the common plenum in the inter-floor spaces, supplemented by exhausts from the bathrooms and the elevator shaft. There were no usable windows in the building, five doors, and three other wall penetrations for the loading dock overhead doors. The temperature was maintained at 70°F, with an average humidity of 55 percent. Special air handling and filtration units were provided for the computer facility contained within the building.

The building received treatment with pesticides twice a month, but had not yet been treated at the time of the first monitoring. Three products were in use by the second visit. These included Ficam-W, a water mixed, pump can sprayed compound used for crawling insects; Whitmeyer PT110 and PT250, both aerosol sprays of low concentration in an unknown propellant, and Talon-G, a rodenticide placed in packets in air chases. Cleaning products used included Sentinel disinfectant/detergent, Seventy-7 synthetic detergent, Old Dutch Cleanser, and Brillo window cleaner.

Immediately prior to and during the first monitoring period, large amounts of mineral spirits were used by the crew installing new furniture. The solvent was used openly with rags to remove adhesives from tables and desks, chairs and counters. The odor was noticeable mainly on the ground floor where the office furniture was being installed. During the third monitoring period, a large mirror was installed in the main lobby of the building. The mirror covered approximately 300 sq. ft. and was secured to the wall with both adhesive and clamps. No other products were reported or observed to be in routine use in the facility.

Monitoring Locations--

During each of the three monitoring visits, five indoor locations and one outdoor location were used. Due to changes in office assignments, and other constraints imposed by the occupants of the building, some of the internal locations varied between visits. Any changes will be indicated as appropriate. During the first visit, location one was an office on the first floor of the building. It contains 144 square feet under the standard nine foot ceiling, and was approximately five feet above grade. Ventilation was provided through one inlet and one outlet to the common plenum. There were no furnishings in the office, and the wall coverings and carpets were brand new. The wall panels were covered with a vinyl film applied with a water-based adhesive to gypsum board panels, while the fixed walls were a standard dry wall covered with a fabric backed vinyl using a Glidden adhesive. This was the standard wall treatment throughout the facility. The carpet was Dupont Antron II nylon with a polypropylene and latex backing, applied with Bigelow Nu-Broadlok glue. This was also the standard floor treatment throughout the building. All areas were vacuumed and dusted every evening.

During the second visit, location one was a different office on the first floor. This office contained 96 square feet, and had the same ventilation, wall treatment, and carpeting as the first office. The furniture in the office was one month old and included a wooden desk, a metal typewriter stand, and a vinyl and cloth covered chair. This same office, being used as a clerical area was visited during the third monitoring period. The only changes were the addition of some furniture and a six square foot particle board. The new furniture included two metal file cabinets, two new metal and vinyl chairs, a computer stand, and a typewriter. No unusual occurrences were observed or reported during any of the three visits. The only sources of chemicals specific to the location were the cleaning products used on a daily basis.

The second monitoring location was a secretarial area in the hallway on the first floor. The area was 378 square feet but was open and connected to other areas and hallways. Ventilation was provided through two inlets, and a single outlet to the common plenum in the inter-floor space. Wall and floor treatment were the same as the rest of the building. A new credenza and two desks were the only furnishings in the area. During the second monitoring period, the second location was a different secretarial area on the first floor. This location contained 375 square feet, with ventilation provided by spillover from other areas, with no specific inlets provided. Wall and floor treatments were standard. Furnishings included three wood and formica desks, a metal file cabinet, a wood sideboard, three metal and vinyl chairs, and three plastic floormats. During the third visit, the second location was a 72 square foot section of hallway located near the two previous locations. The location was just outside the central computer facility which was equipped with Halon fire suppression systems. There was one air inlet located in the area, as well as one duct to the common plenum. The only furniture in the location was one wood and metal table.

The third monitoring location during the first visit was a 144 square foot office on the second floor of the building. Ventilation included one air inlet, and a duct to the common plenum. Wall and floor treatments were standard. There was no furniture in the office during the monitoring period, until the last day when a wooden desk was moved into the office. The same office was used in the second monitoring period. The only observed difference was the addition of furniture, including a desk chair, two side chairs, and a wooden file, in addition to the desk from the first visit. No additional sources of chemicals were observed or reported. During the third visit, a new second floor office was monitored. It contained 144 square feet of space, with the standard wall and floor treatments, and one air inlet. The furniture in the office included three side chairs, a wood desk, a wood credenza, a wood bookcase, a metal file cabinet, and a desk chair.

The fourth monitoring location was the same for all three visits. It was a 168 square foot secretarial area located in the hallway adjacent to the offices monitored as the third site. Ventilation included one inlet, one duct to the common plenum, and mixing along the open hallway. Wall and floor treatments were the building standard. During the first visit, furnishings included a wood/formica/metal desk and a wood and vinyl chair. At the second visit, a second desk and chair had been added, as well as a wooden file cabinet, and two plastic chair pads. No changes were noted between the second and third visits.

The fifth monitoring location was the same for all three visits, and was a small interior room on the third floor used to house a photocopier. The room was 132 square feet in area and was located approximately 29 feet above grade. Ventilation was through one inlet and one outlet. The wall and floor treatments were as previously described for other areas of the building. During the first period, the room was empty. At the second visit, there were three metal bookcases containing miscellaneous office supplies, a metal and formica table, and a Canon copier. The only change at the third visit was the addition of a second identical copying machine.

The sixth location was also constant across the visits. It was an outside location near the main air intakes for the building. The monitoring equipment was located on a concrete slab, on the east side of the building, and was exposed to all changes in ambient conditions. No specific sources of chemicals were observed or reported in the area around this location during any of the monitoring periods.

SECTION 6
SAMPLE ANALYSIS

All samples collected during field monitoring (Section 4) were analyzed using the protocols described in the Draft Work Plan, Part II: Analytical Protocols.(1) In this section, details of sample analysis are given for each parameter including analytical method, method validation experiments, limits of detection, QC results, and quantitation method. Table 21 summarizes information on the number of samples collected and analyzed for each of eight parameters during each sampling trip.

VOLATILE ORGANICS

Analytical Method

Recovery of volatile organics from Tenax GC was accomplished by thermal desorption and purging with helium into a liquid nitrogen cooled, nickel capillary trap.(2-4) The vapors were then introduced into a high resolution fused silica chromatographic column for component separation.(3,5) Characterization and quantification of the constituents in the sample were accomplished by electron impact mass spectrometry by measuring the intensity of the extracted ion current profile.(3,6,7) Gas chromatography/mass spectrometry (GC/MS) conditions used during sample analysis are given in Table 22.

Immediately prior to GC/MS analyses each Tenax cartridges was loaded with perfluorotoluene (~150 ng) and perfluorobenzene (~50 ng) to serve as external quantitation standards. Quantitation of GC/MS results was accomplished using relative response factors (RRF). RRF values for each target chemical were generated by analyzing standard cartridges loaded with known amounts of targets and external standard (ES). For any target chemical (T), the RRF was then calculated as:

$$\frac{A_T \cdot ng_{ES}}{A_{ES} \cdot ng_T}$$

TABLE 21. SAMPLE ANALYSIS

Parameter	Facility	Visit	No. of Samples Scheduled	Collected	Analyzed
Volatile Organics	Office	1	24	24	24
		2	24	22	22
		3	24	24	24
	School	1	24	23	23
	Elderly home	1	36	36	36
		2	30	30	29
Inhalable Particulates	Office	1	8	6	6
		2	8	6	SL[a]
		3	8	7	7
	School	1	0	0	0
	Elderly home	1	18	18	17
		2	15	13	12
Pesticides/PCBs	Office	1	12	12	12
		2	12	12	12
		3	12	11	11
	School	1	12	12	11
	Elderly home	1	18	18	18
		2	15	15	13
Formaldehyde	Office	1	12	12	SL[a]
		2	12	12	12
		3	12	12	12
	School	1	12	12	12
	Elderly home	1	18	17	17
		2	15	15	15

(continued)

TABLE 21. (cont'd.)

Parameter	Facility	Visit	No. of Samples		
			Scheduled	Collected	Analyzed
Metals	Office	1	12	12	11
		2	12	10	10
		3	12	11	11
	School	1	12	8	8
	Elderly home	1	18	18	16
		2	15	15	15
CO	None collected				
NO_2	None collected				
Air exchange	Office	1	16	12	12
		2	16	14	14
		3	16	14	14
	School	1	18	17	17
	Elderly home	1	20	17	17
		2	24	24	24

[a] Samples lost.

TABLE 22. OPERATING PARAMETERS FOR GC/MS SYSTEM

Parameter	Setting
Inlet-manifold:	
Desorption Chamber and Valve:	270°C
Capillary Trap - minimum:	-195°C
- maximum:	240°C
Thermal Desorption Time:	8 min
He purge flow:	15 mL/min
GC Conditions:	
60 m DB-1 Wide Bore Fused Silica:	40°C (hold 5 min) - 240°C, 4°C/min
Carrier (He) Flow:	1.0 mL/min
Separator Oven:	240°C
MS Conditions:	
Finnigan 3300:	
Scan Range:	m/z 35 to 350
Scan Cycle, automatic:	1.9 sec/cycle
Hold Time:	0.1 sec
Filament Current:	0.5 mA
Electron multiplier:	1600 volts

A_T is the peak area of target compound and ng_T are the ng of target compound loaded onto the cartridge. Likewise, A_{ES} and ng_{ES} are the peak area and amount loaded of the external standard.

Relative response factors were determined prior to the analysis of any sample cartridges for each field monitoring trip by establishing a data base of response factors using eight to fifteen standard cartridges. RRFs for each cartridge were calculated. After eliminating obvious outliers in this data base, the average RRF and its standard deviation were calculated for each target volatile.

During each day of sample analysis, two additional standard cartridges were analyzed. If the RRFs calculated for these cartridges fell within ±3 S.D. of the average response factor, then the GC/MS system was considered in control and the average RRF was used to quantitate targets on sample cartridges using the following equation:

$$ng_T = \frac{A_T \cdot ng_{ES}}{A_{ES} \cdot RRF_T}$$

where ng_T is the amount of target volatile present on the sample cartridge.

Relative response factors and control limits used for quantitating each set of field samples are listed in Table 23. Data from this table illustrate that for several of the target volatiles including benzene, trichloroethylene, tetrachloroethylene, chlorobenzene, styrene, and ethyl benzene, a large variation in relative response factors was considered acceptable.

Method Validation

Loading of External Standards--

Before each Tenax cartridge was analyzed, known amounts of two external standards, perfluorobenzene (PFB) and perfluorotoluene (PFT), were added as a vapor mixture for sample quantitation. A small study was conducted to determine the reproducibility of this operation. Several cartridges were loaded with PFB and PFT using a permeation system with a 10 mL gas syringe. Once loaded, cartridges were thermally desorbed and analyzed by GC/FID. Chromatographic peak areas were determined using an electronic integrator. Results shown in Table 24 demonstrate reproducible loading using this technique.

TABLE 23. RELATIVE RESPONSE FACTORS (RRF) USED FOR QUANTITATION OF VOLATILE ORGANICS

Target Volatile	Ion	Mean RRF ± SD (Control Limits)				
		I[a]	II[b]	III[c]	IV[d]	V[e]
1,1,1-trichloroethane	61	0.56±0.18(0.19-0.96)	0.23±0.00(0.22-0.24)	0.15±0.03(0.08-0.23)	0.15±0.03(0.08-0.23)	0.40±0.11(0.08-0.71)
	97	1.12±0.29(0.26-1.97)	0.49±0.03(0.41-0.57)	0.30±0.05(0.14-0.45)	0.47±0.03(0.40-0.55)	0.87±0.20(0.28-1.46)
	99	0.71±0.17(0.19-1.24)	0.29±0.02(0.24-0.34)	0.19±0.03(0.09-0.30)	0.30±0.02(0.26-0.35)	0.56±0.13(0.18-0.94)
carbon tetrachloride	117	0.88±0.16(0.39-1.37)	0.32±0.03(0.22-0.42)	0.16±0.02(0.09-0.23)	0.30±0.01(0.26-0.34)	0.73±0.13(0.34-1.12)
	119	0.88±0.16(0.37-1.32)	0.31±0.03(0.21-0.41)	0.16±0.02(0.09-0.22)	0.30±0.01(0.25-0.34)	0.72±0.12(0.35-1.09)
chloroform	83	1.69±0.37(0.59-2.78)	0.86±0.02(0.78-0.94)	0.84±0.06(0.65-1.04)	0.80±0.03(0.72-0.57)	1.03±0.04(0.90-1.16)
	85	1.08±0.24(0.38-1.79)	0.52±0.01(0.48-0.56)	0.55±0.04(0.43-0.67)	0.52±0.02(0.47-0.59)	0.78±0.14(0.59-0.76)
1,2-dichloroethane	62	1.46±0.32(0.49-2.43)	0.58±0.01(0.54-0.62)	0.49±0.08(0.24-0.75)	0.54±0.02(0.47-0.59)	0.78±0.14(0.37-1.19)
	64	0.45±0.10(0.15-0.75)	0.18±0.00(0.17-0.19)	0.14±0.24(0.07-0.22)	0.17±0.01(0.15-0.19)	0.25±0.05(0.11-0.40)
benzene	78	3.99±0.72(1.84-6.14)	1.91±0.03(1.81-2.01)	0.83±0.12(0.47-1.18)	2.22±0.76(0-4.50)	2.91±0.63(1.02-4.81)
trichloroethylene	95	0.99±0.25(0.23-1.75)	0.48±0.02(0.41-0.55)	0.24±0.09(0-0.52)	0.28±0.03(0.19-0.37)	0.94±0.19(0.36-1.51)
	130	1.02±0.26(0.25-1.80)	0.53±0.02(0.47-0.60)	0.25±0.10(0-0.54)	0.32±0.03(0.23-0.41)	0.97±0.18(0.42-1.51)
	132	0.97±0.24(0.24-1.69)	0.50±0.02(0.44-0.56)	0.23±0.09(0-0.49)	0.30±0.03(0.22-0.39)	0.94±0.16(0.42-1.51)
tetrachloroethylene	164	0.98±0.23(0.28-1.68)	0.29±0.01(0.26-0.32)	0.52±0.15(0.07-0.96)	0.32±0.12(0-0.66)	0.85±0.06(0.66-1.03)
	166	1.24±0.29(0.37-2.11)	0.32±0.01(0.28-0.36)	0.64±0.19(0.11-1.18)	0.41±0.14(0-0.84)	1.02±0.08(0.80-1.25)
chlorobenzene	77	1.85±0.40(0.66-3.43)	0.44±0.01(0.42-0.46)	1.10±0.14(0.69-1.51)	0.62±0.33(0-1.60)	1.87±0.14(1.45-2.28)
	112	3.35±0.73(1.24-5.46)	0.83±0.01(0.80-0.86)	2.10±0.27(1.28-2.91)	1.24±0.64(0-3.17)	3.51±0.26(2.73-4.28)
	114	1.04±0.22(0.39-1.69)	0.52±0.01(0.50-0.54)	0.63±0.82(0.39-0.88)	0.38±0.20(0-0.97)	1.12±0.08(0.88-1.35)
1,1,2,2-tetrachloroethane	83	2.16±0.32(1.20-3.12)	1.49±0.11(1.15-1.82)	1.48±0.11(1.14-1.18)	1.14±0.16(0.65-1.63)	1.49±0.19(0.93-2.06)
	166	0.12±0.02(0.07-0.17)	0.09±0.01(0.07-0.11)	0.09±0.01(0.07-0.27)	0.07±0.01(0.04-0.10)	0.10±0.01(0.07-0.13)
	168	0.15±0.02(0.08-0.22)	0.12±0.01(0.10-0.14)	0.11±0.01(0.10-0.13)	0.09±0.01(0.05-0.13)	0.12±0.01(0.08-0.161)

(continued)

TABLE 23. (cont'd.)

Target Volatile	Ion	Mean RRF ± SD (Control Limits)				
		I[a]	II[b]	III[c]	IV[d]	V[e]
p-dichlorobenzene	146	3.06±0.28(2.21-3.91)	1.40±0.08(1.38-1.42)	1.84±0.21(1.21-2.48)	1.34±0.10(1.04-1.64)	1.85±0.18(1.32-2.37)
	148	1.88±0.18(1.34-2.41)	0.83±0.05(0.58-0.98)	1.12±0.13(7.38-1.51)	0.82±0.06(0.64-1.01)	1.15±0.11(0.82-1.47)
o-dichlorobenzene	146	2.83±0.28(2.00-3.67)	1.29±0.09(1.02-1.56)	1.77±0.19(1.19-2.35)	1.29±0.01(1.02-1.56)	2.04±0.18(1.50-2.59)
	148	1.74±0.17(1.22-2.26)	0.77±0.05(0.62-0.92)	1.08±0.12(0.72-1.43)	0.79±0.05(0.63-0.95)	1.26±0.12(0.91-1.61)
styrene	104	3.52±0.38(2.39-4.65)	1.64±0.14(1.22-2.06)	2.11±0.22(1.44-2.78)	1.56±0.16(1.09-2.04)	2.23±0.29(0.35-3.11)
ethyl benzene	91	4.61±0.46(3.23-5.99)	1.40±0.71(0-3.53)	2.70±0.45(1.36-4.04)	1.78±0.48(0.34-3.23)	2.72±0.37(1.64-3.84)
	126	1.59±0.16(1.09-2.08)	0.43±0.24(0-1.15)	0.87±0.15(0.41-1.33)	0.60±0.18(0.07-1.12)	1.25±0.17(0.74-1.75)
p-xylene	91	3.67±0.26(2.88-4.47)	1.56±0.42(0.30-2.82)	2.26±0.22(1.59-2.93)	1.48±0.21(0.86-2.10)	2.33±0.33(1.34-3.32)
	106	2.01±0.19(1.43-2.58)	0.84±0.24(0.36-1.32)	1.19±0.10(0.88-1.50)	0.86±0.13(0.48-1.24)	1.56±0.21(0.92-2.20)
o-xylene	91	3.70±0.42(2.43-4.97)	1.79±0.15(1.49-2.19)	2.38±0.34(1.36-3.39)	1.59±0.15(1.13-2.05)	2.31±0.31(1.39-3.23)
	106	1.95±0.19(1.39-2.52)	0.90±0.07(0.86-1.04)	1.18±0.16(0.71-1.64)	0.86±0.08(0.61-1.10)	1.48±0.19(0.91-2.05)
n-decane	57	NC[f]	NC	NC	NC	1.57±0.22(0.90-2.23)
	85	NC	NC	NC	NC	0.52±0.08(0.28-0.74)
	142	NC	NC	NC	NC	0.15±0.02(0.09-0.20)
n-undecane	57	NC	NC	NC	NC	2.33±0.34(1.31-3.34)
	85	NC	NC	NC	NC	0.66±0.09(0.38-0.93)
	156	NC	NC	NC	NC	0.17±0.02(0.11-0.23)
n-dodecane	57	NC	NC	NC	NC	2.39±0.34(1.36-3.42)
	85	NC	NC	NC	NC	0.75±0.10(0.45-1.05)
	170	NC	NC	NC	NC	0.16±0.02(0.11-0.22)

[a] I - Elderly home-1

[b] II - School

[c] III - Office-1

[d] IV - Office-2

[e] V - Office-3 and Elderly home-2

[f] Not Calibrated

TABLE 24. EXTERNAL STANDARDS LOADED FROM PERMEATION SYSTEM AND ANALYZED BY GC/FID

Date Analyzed	Area PFB x 10^3	Area PFT x 10^3	Comments
4-6-83	757.9	470.7	
4-6-83	∼750.0	500.3	Interference in PFB - Integrated manually
4-6-83	735.2	452.8	
4-6-83	842.1	509.1	
4-6-83	826.2	475.5	
4-7-83	762.4	556.1	
4-8-83	∼815.1	∼550	Interference in PFB & PFT
4-8-83	888.1	∼580	Interference in PFT
4-12-83	712.5	636.7	
Mean ± S.D. (CV)	787.7 ± 58 (7.3)	525.7 ± 60 (11)	

Limits of Detection

Instrumental limits of detection (LOD) and quantitation limits (QL) were calculated from the data base generated for relative response factor determinations. The limits of detection was defined as the ng/cartridges required to give 500 area counts during analysis, assuming a linear response for the GC/MS system. The QL was equal to 4X the LOD or the number of ng/cartridge which would correspond to 2000 area counts. The calculations for LOD and QL may be expressed as:

$$\mathrm{LOD} = \frac{ng_T \cdot 500}{A_T}$$

$$\mathrm{QL} = \frac{ng_T \cdot 2000}{A_T}$$

where ng_T is the amount of target loaded onto the standard cartridges and A_T is the average GC/MS area response resulting from analysis of the standard cartridge. Values for LOD and QL used during analysis for each field monitoring are tabulated in Table 25.

QC Results

Sets of quality control samples were prepared for each sampling trip. Each set contained an unspiked cartridge to serve as a blank and two spiked cartridges which served as controls. Cartridges were spiked with 100-500 ng target compounds (see Tables 8 and 9). All field controls and blanks were analyzed. During the first three trips, the laboratory controls and blanks were also analyzed; however, during later trips laboratory QC samples were processed only if poor results were obtained from the field QC samples. Results of QC analysis are given in Tables 26 and 27. Percent recovery was calculated as:

$$\%\ \mathrm{Recovery} = \frac{ng_{FC} - ng_{FB}}{ng_{spiked}} \times 100\%$$

where ng_{FC} is the average amount of target compound found on field controls;
ng_{FB} is the average amount of target compound found on field blanks; and
ng_{spiked} is the amount of target compound spiked onto field controls.

TABLE 25. INSTRUMENTAL LODs AND QLs FOR VOLATILE ORGANIC COMPOUNDS

	ng/cartridge									
	I[a]		II[b]		III[c]		IV[d]		V[e]	
Compound	LOD	QL	LOD	QL	LOD	QL	LOD	QL	LOD	QL
1,1,1-Trichloroethane	1	4	1	4	2	8	1	4	1	4
Carbon tetrachloride	1	4	1	4	3	12	2	8	2	8
Chloroform	1	4	1	4	1	4	1	4	1	4
1,2-Dichloroethane	1	4	1	4	1	4	1	4	1	4
Benzene	1	4	1	4	1	4	1	4	1	4
Trichloroethylene	1	4	1	4	2	8	3	12	2	8
Tetrachloroethylene	1	4	1	4	2	8	2	8	1	4
Chlorobenzene	1	4	1	4	1	4	1	4	1	4
1,1,2,2-Tetrachloroethane	1	4	1	4	1	4	1	4	1	4
Styrene	1	4	1	4	1	4	1	4	1	4
p-Dichlorobenzene	1	4	1	4	1	4	1	4	1	4
o-Dichlorobenzene	1	4	1	4	1	4	1	4	1	4
Ethylbenzene	1	4	1	4	1	4	1	4	1	4
o-Xylene	1	4	1	4	1	4	1	4	1	4
p-Xylene	1	4	1	4	1	4	1	4	1	4
n-Decane	ND[f]	ND	ND	ND	ND	ND	ND	ND	1	4
n-Undecane	ND	ND	ND	ND	ND	ND	ND	ND	1	4
n-Dodecane	ND	ND	ND	ND	ND	ND	ND	ND	1	4

[a] Elderly home-1

[b] School

[c] Office - Trip 1

[d] Office - Trip 2

[e] Office - Trip 3 and Elderly home-2

[f] ND - Not determined

TABLE 26. PERCENT RECOVERY FOR TARGET VOLATILES FROM FIELD CONTROL SAMPLES

Compound	% Recovery ± S.D.[a]					
	Elderly home-1	School	Office - trip 1	Office - trip 2	Office - trip 3	Elderly home-2
Chloroform	77±5	105±14	122±4	89±3	86±12	103±8
1,2-Dichloroethane	80±4	99±16	154±5	98±5	122±28	105±16
1,1,1-Trichloroethane	99±14	98±28	180±8	92±4	110±32	116±28
Benzene	76±7	79±33	245±7	67±4	101±9	81±18
Carbon tetrachloride	79±3	79±23	194±2	108±9	109±12	86±13
Trichloroethylene	87±4	64±09	219±6	126±49	111±8	82±18
Tetrachloroethylene	91±5	89±19	45±6	102±42	100±9	99±6
Chlorobenzene	93±4	120±60	108±3	93±59	94±10	96±8
Styrene	85±4	87±51	113[b]	112[b]	107±8	112±19
m&p-Dichlorobenzene	82±5	114±18	108[b]	109[b]	109±13	110±5
o-Dichlorobenzene	76±3	86±14	107[b]	108[b]	104±12	106±5
Ethylbenzene	87±3	121±70	119[b]	133[b]	104±9	104±6
o-Xylene	87±4	87±47	113[b]	112[b]	106±8	102±7
m&p-Xylene	89±7	100±43	118[b]	118[b]	107±8	102±5
1,1,2,2-Tetrachlorobenzene	82±2	92±32	113[b]	72±27	94±15	104±3
n-Decane	NT[c]	NT	NT	NT	124±15	117±17
n-Undecane	NT	NT	NT	NT	99±14	110±7
n-Dodecane	NT	NT	NT	NT	97±14	98±9

[a] Triplicate determinations.

[b] Duplicate determinations - one control lost during analysis.

[c] Not Tested; compounds were not targets at the start of the study.

TABLE 27. LEVEL OF TARGET VOLATILES FOUND ON FIELD BLANKS

	ng ± S.D./cartridge[a]					
Compound	Elderly home-1	School	Office - trip 1	Office - trip 2	Office - trip 3	Elderly home-2
Chloroform	2±1	6±5	4±1	4[b]	35±28	10±61
1,2-Dichloroethane	ND[c]	ND	ND	ND[b]	ND	ND
1,1,1-Trichloroethane	50±21	17±5	9±2	1[b]	7±6	14±11
Benzene	42±16	21±12	58±22	48[b]	23±12	31±13
Carbon tetrachloride	ND	ND	ND	ND[b]	1±1	2±2
Trichloroethylene	2±3	1±1	4±2	2[b]	2±2	3±2
Tetrachloroethylene	ND	ND	ND	ND[b]	ND	1±1
Chlorobenzene	1±1	1±1	1±1	1[b]	2±1	2±0
Styrene	3±2	1±1	8±11	14[b]	2±1	131±11[d]
m&p-Dichlorobenzene	4±1	4±2	2±0	0[b]	ND	1±1
o-Dichlorobenzene	1±2	1±1	ND	ND[b]	2±3	2±2
Ethylbenzene	1±0	1±1	3±2	3[b]	1±1	10±3
o-Xylene	1±0	1±1	1±1	1[b]	1±1	5±2
m&p-Xylene	2±1	4±1	4±1	3[b]	3±2	9±4
1,1,2,2-Tetrachloroethane	3±7	ND	ND	ND[b]	ND	ND
n-Decane	6±2	ND	ND	0[b]	ND	ND
n-Undecane	3±1	14±14	8±5	3[b]	5±6	4±1
n-Dodecane	1±1	1±1	4±3	2[b]	2±1	4±1

[a] Triplicate determinations.

[b] Duplicate determinations.

[c] Not Detected.

[d] Very high level also found on laboratory blanks and control cartridges.

Data shows generally acceptable recoveries for field controls. Exceptions were the high recoveries for 1,2-dichloroethane, 1,1,1-trichloroethane, benzene, carbon tetrachloride, and trichloroethylene noted during the first trip to the office building. An examination of the GC/MS calibration data showed that the relative response factors used to quantitate samples for the targets were much lower than the relative response factors calculated from standard cartridges run the day of the analysis. This discrepancy would result in calculating erroneously high levels of the target compounds per cartridge and hence give high recovery values. Although the high recovery values make data for these targets from the first trip to the office suspect, adjusting concentrations found on field cartridges by recovery should help minimize the error. It should be noted that although most of the RRFs calculated from the daily standards were considered in control, significant quantitation errors resulted. This emphasizes the necessity for imposing more rigorous control limits in future studies.

Analysis of field blanks showed fairly high background levels of benzene and 1,1,1-trichloroethane. Contamination with 1,1,1-trichloroethane was greatest at the elderly home-1. High levels of styrene were found on both field blanks from the elderly home-2. High levels of chloroform were found on field blanks from the third trip to the office building.

Sample Analysis

Table 21 shows the number of samples for volatile organics both collected and analyzed for each field monitoring trip.

As described previously, output from the GC/MS analysis was ng of target per cartridge (ng_T). This raw mass was then corrected for background by subtracting mean values for each target (BKG) as determined from field blank cartridges. The mean target values for field control cartridges (spiked with known amounts of each target) allowed for calculation of recovery. These were used to correct the background subtracted mass/cartridge values for recovery. Thus, the final, corrected mass determination was calculated as:

$$\text{Total ng} = \frac{ng_T - \overline{BKG}}{\text{recovery}}$$

Since the volume of air drawn through each cartridge sample was known and the quantity of substance per cartridge can be determined, when the breakthrough volume is not exceeded, the level in ambient air is given by:

$$\frac{\mu g}{m^3} = \frac{\text{Total ng}}{\text{Volume Sampled (L)}}$$

If the breakthrough volume was exceeded, the "Total ng" calculated was divided by the breakthrough volume to give an ambient air concentration value that represents the best estimate of the concentration, assuming a constant concentration throughout the sampling period.

Pesticides/PCBs

Recovery of target pesticides/PCBs from polyurethane foam (PUF) plugs was accomplished by a 14 h soxhlet extraction of the PUF with 150 mL of hexane. The hexane was concentrated to 1 mL by Kuderna-Danish evaporation followed by nitrogen blowdown.

Samples from the elderly home-1 and the primary school were fractionated using florisil open column chromatography. Each fraction was then concentrated to 1 mL using nitrogen blowdown. Chromatographic conditions and fractionation pattern of the target pesticides and PCBs are given in Table 28. Samples from the remaining four field trips were analyzed without fractionation since this procedure did not significantly improve the ability to quantitate target chemicals, but did significantly increase analysis time.

An external standard, octachloronaphthalene, was added to each sample or sample fraction prior to GC analysis. All samples were analyzed by GC/ECD using the conditions described in Table 29. Chromatograms of target compounds are given in Figures 11 to 14. Target compounds in PUF extracts were quantitated using relative response factors (RRF) generated for each pesticide, PCB, and chlordane peak. RRF values were generated by analyzing standard solutions (Table 30) prepared in hexane containing known concentrations of each target and the external standard. For the target pesticide, the RRF was calculated as:

$$RRF = \frac{A_P \cdot pg_P}{A_{ES} \cdot pg_{ES}}$$

TABLE 28. FRACTIONATION PATTERN OF TARGET PESTICIDES AND PCBs DURING FLORISIL CHROMATOGRAPHY[a]

Compound	Fraction I	Fraction II
α-BHC	x	
HCB	x	x
γ-BHC		x
β-BHC		x
Heptachlor	x	
Oxychlordane		x
Heptachlor Epoxide		x
p,p'-DDE	x	
p,p'-DDD		x
p,p'-DDT		x
tech. Chlordane	x	x
Arochlor 1260	x	

[a] 10 g of florisil eluted 50 mL of hexane (Fraction I) and 50 mL of 5% methyl-t-butyl ether in hexane (Fraction II).

TABLE 29. OPERATING CONDITIONS FOR GC/ECD ANALYSIS OF TARGET PESTICIDES AND PCBs

Parameter	Specification
Column:	1% SE 30 on Supelcoport
Nitrogen Carrier Flow:	25 mL/min
Temperatures:	
Injector:	220°C
Column:	120°C to 220°C @ 5°C/min; final time, 15 min
Detector:	260°C
Detector Type:	Ni^{63} ECD

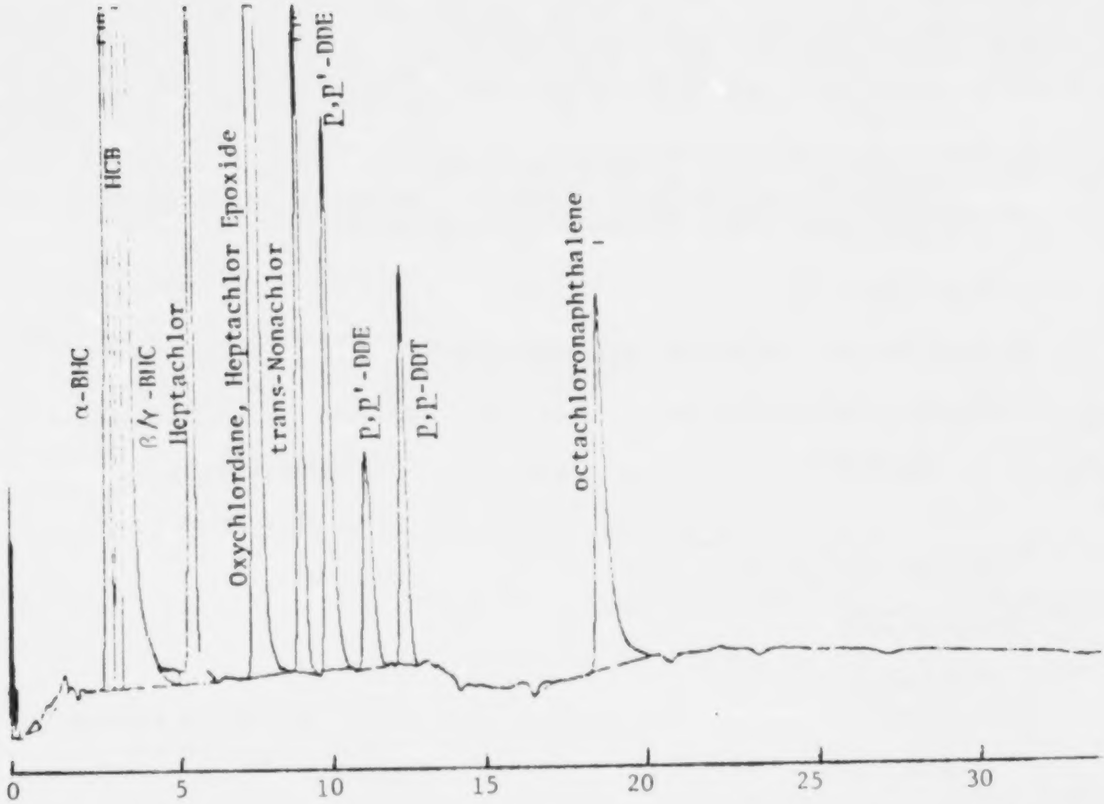

Figure 11. Chromatogram of target pesticides analyzed by GC/ECD.

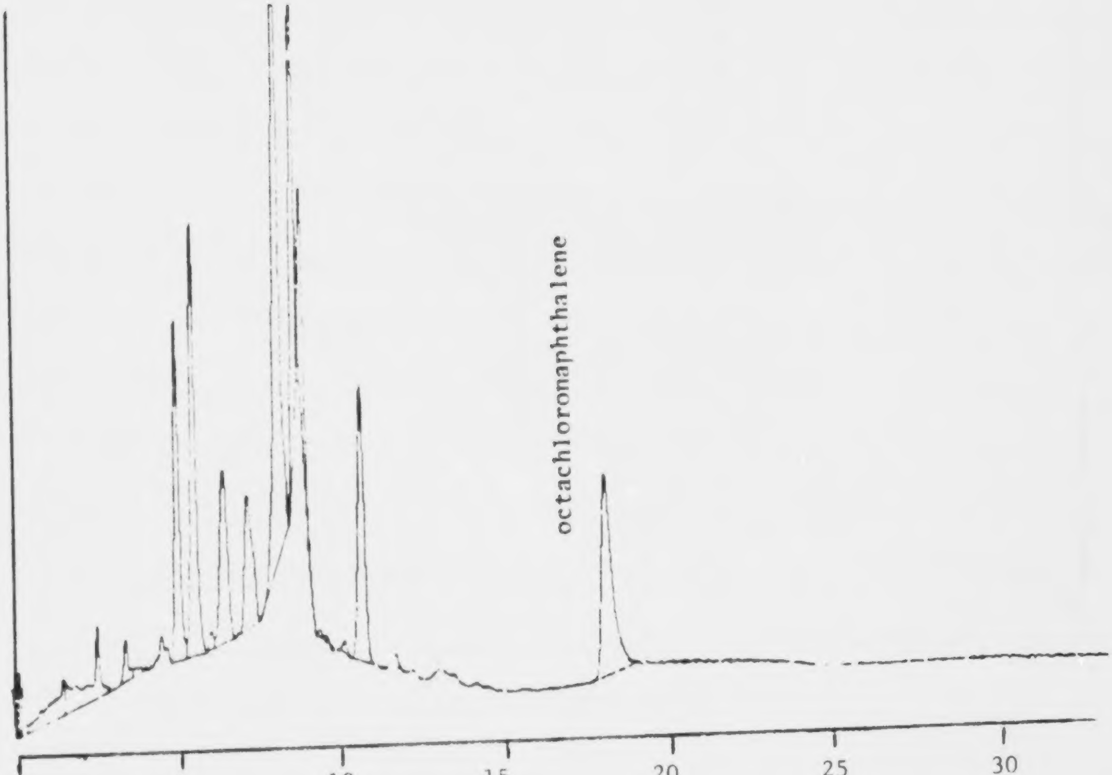

Figure 12. Chromatogram of technical Chlordane analyzed by GC/ECD.

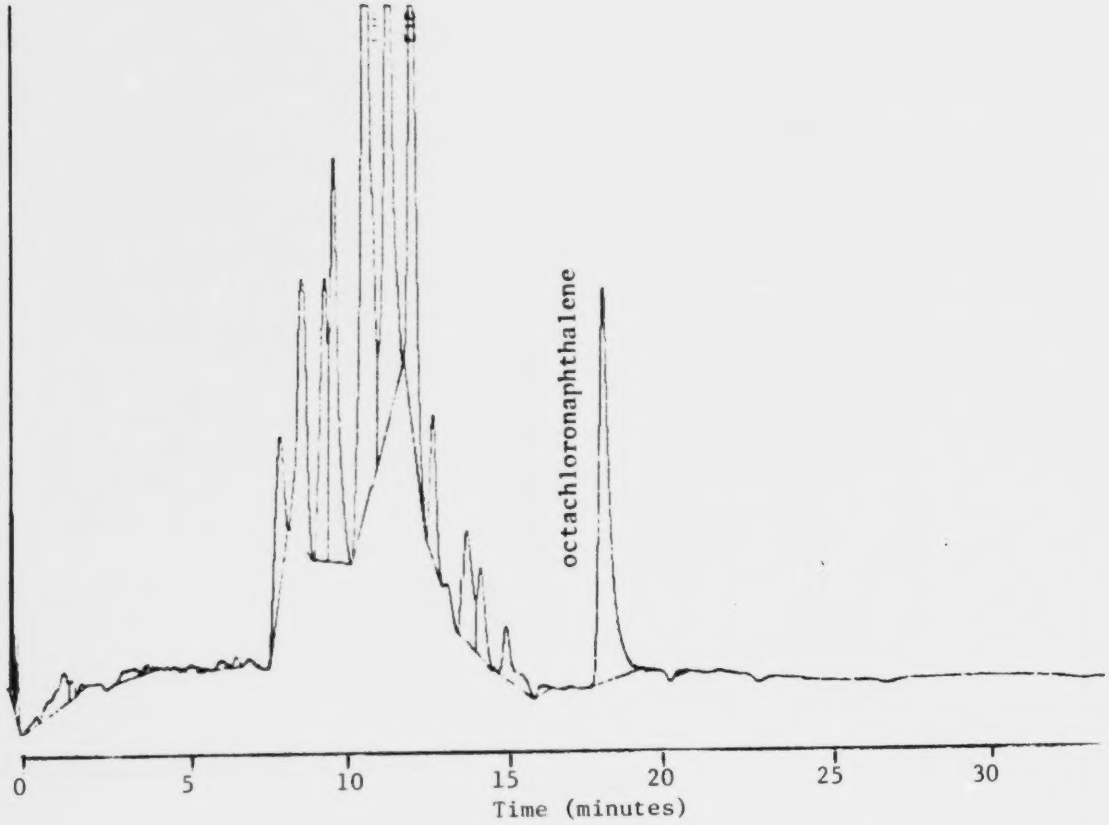

Figure 13. Chromatogram of Aroclor 1254 analyzed by GC/ECD.

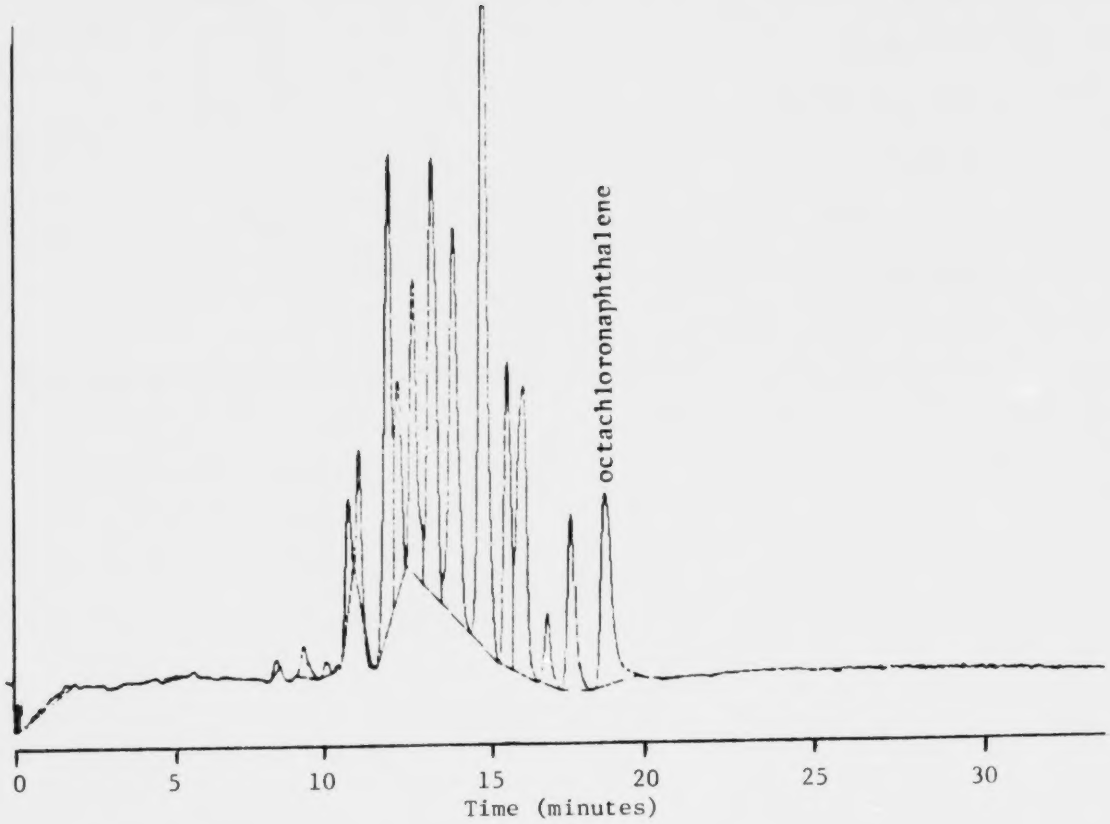

Figure 14. Chromatogram of Aroclor 1260 analyzed by GC/ECD.

TABLE 30. CALIBRATION STANDARDS FOR PESTICIDE/PCB ANALYSIS

Compound	Concentration (pg/μL)
Solution 1	
α-BHC	8.48
HCB	9.28
β,γ-BHC	28.32
Heptachlor	7.68
Heptachlor epoxide	7.35
trans-Nonachlor	9.41
p,*p*'-DDE	8.96
p,*p*'-DDD	7.28
p,*p*'-DDT	8.96
Solution 2	
tech. Chlordane	72.0
Solution 3	
Aroclor 1254	247
Solution 4	
Aroclor 1260	230

where A_P and A_{ES} are the peak areas measured for the pesticide and external standard, respectively and pg_P and pg_{ES} are the pg of the pesticide and ES injected onto the GC column. For the PCBs, RRFs were generated for both Aroclor 1254 and Aroclor 1260 using the Webb McCall method.(8) For technical chlordane, it was assumed that each peak in the GC pattern resulted from an equal amount of chlordane. Since there were eight peaks for quantitation (Figure 12), the relative response factor for any individual peak (RRF_i) was calculated as:

$$RRF_i = \frac{A_i \bullet pg_{t8}}{A_{ES} \bullet pg_{ES}}$$

where A_i is the area of response of peak i and pg_t is the pg of technical chlordane injected into the GC column. Prior to analysis of PUF extracts, RRF factors were calculated from triplicate injections of the standards listed in Table 30. Each day samples were analyzed, the standards were reanalyzed, and new RRFs generated. The daily RRFs were used for sample quantitation. Table 31 lists the relative response factors used during quantitation.

Detector linearity was demonstrated between 0.4 pg and ~10 ng for all of the target pesticides, between 12.4 pg and 124 ng for technical chlordane, and between 77 pg and 23.6 ng for Aroclor 1254. Correlation coefficients of least squares analysis for each target were generally greater than 0.99 for calibration curves generated in the above ranges.

Limits of Detection Quantitation Limits

Estimated quantitation limits (QL) were calculated from the data base generated for relative response factor determinations. During sample analysis, the data acquisition system was set with a lower threshold limit of 500,000 area counts. In other words, any chromatographic peak with less than 500,000 area counts would not be recognized as a peak, therefore, no data would be acquired. Under these conditions, the estimated quantitation limits were defined as the number of pg injected onto the GC column which would give 500,000 area counts during analysis. The calculation for QL may be expressed as:

$$QL = \frac{pg_p \bullet 500,000}{A_p}$$

TABLE 31. RELATIVE RESPONSE FACTORS (RRF) GENERATED FOR THE QUANTITATION OF PUF EXTRACTS

Compound	Daily RRF										
α-BHC	0.52	0.52	0.40	0.63	0.48	0.52	0.48	0.57	0.44	0.58	0.56
HCB	0.68	0.56	0.38	0.65	0.57	0.56	0.39	0.48	0.36	0.48	0.44
β,γ-BHC	0.70	0.77	0.68	0.99	0.69	0.77	1.02	1.07	0.83	1.26	1.18
Heptclor	0.55	0.53	0.48	0.72	0.53	0.53	0.65	0.69	0.50	0.71	0.68
Hept. Epox.	0.53	0.46	0.50	0.63	0.49	0.46	0.58	0.51	0.48	0.73	0.69
t-Nonachlor	0.72	0.79	0.63	0.68	0.69	0.79	0.87	1.02	1.05	0.92	0.95
p,p'-DDE	0.67	0.73	0.55	0.60	0.62	0.73	0.71	0.82	0.67	0.77	0.79
p,p'-DDD	1.54	1.36	1.06	1.21	1.28	1.36	1.03	1.26	0.90	1.18	1.23
p,p'-DDT	1.28	1.18	1.03	1.08	1.03	1.18	1.31	0.88	1.75	0.96	0.58
CLOR 1[a]	0.70	0.79	0.78	0.71	0.78	0.69	0.98	1.08	1.08	0.88	0.91
CLOR 2	0.64	0.69	0.69	0.62	0.65	0.56	0.88	0.87	0.87	0.73	0.75
CLOR 3	0.66	NC[b]	0.75	0.67	0.68	0.60	0.80	0.85	0.85	0.77	0.72
CLOR 4	0.70	NC	0.81	0.72	0.72	0.65	0.83	0.87	0.98	0.78	0.80
CLOR 5	0.66	0.74	0.77	0.70	0.72	0.67	0.80	0.83	0.83	0.76	0.79
CLOR 6	0.98	1.12	1.16	0.70	1.07	1.03	1.19	1.22	1.22	0.81	0.84
CLOR 7	1.58	1.70	1.84	0.72	1.70	1.57	1.91	2.04	2.04	0.83	0.87
CLOR 8	0.71	0.78	0.81	0.72	0.75	0.67	0.93	1.01	1.01	0.82	0.87
PCB 70[c]	7.81	7.54	NC	7.57	5.69	5.49	4.88	5.52	5.12	5.50	5.50
PCB 84	4.24	4.68	3.82	4.68	4.28	4.21	6.91	8.74	4.64	4.97	5.08
PCB 104	8.55	17.90	10.1	17.9	16.5	9.22	10.8	11.2	10.5	11.2	11.5
PCB 125	3.80	4.62	4.91	4.62	2.37	2.23	1.17	3.10	2.56	2.66	2.74
PCB 146	3.24	3.72	3.43	3.73	2.04	1.92	1.14	4.87	2.21	2.24	2.45
PCB 174	1.64	1.74	1.98	1.74	1.70	1.67	1.02	1.17	1.81	1.84	1.99
PCB 70[d]	6.11	5.99	6.10	5.59	5.57	9.87	6.08	6.09	5.31	NC	NC
PCB 84	0.51	0.47	0.51	0.47	NC	0.50	0.57	0.56	0.55	0.39	0.39
PCB 104	8.96	8.43	8.60	8.16	8.17	9.62	8.18	8.14	7.74	NC	11.6
PCB 117	1.22	4.20	1.21	1.11	NC	1.1	1.29	1.29	1.20	0.83	0.89
PCB 125	3.48	3.46	3.34	3.18	3.16	3.29	3.98	3.97	3.67	2.53	2.65
PCB 146	3.85	3.84	4.34	3.86	3.87	3.53	2.71	2.70	2.70	1.85	1.91
PCB 174	2.68	2.59	2.89	2.46	2.45	2.46	2.29	2.28	2.26	1.60	1.52
PCB 203	1.17	1.15	1.22	1.08	NC	1.10	1.15	1.14	1.15	0.82	0.83
PCB 232	1.33	1.33	1.39	1.29	1.28	1.24	1.30	1.30	1.30	0.91	0.93
PCB 280	1.35	0.72	0.76	0.70	0.70	0.68	0.59	0.59	0.74	0.51	0.51
PCB 332	3.41	3.00	3.87	3.25	3.26	2.78	2.17	2.16	2.13	1.45	1.48
PCB 372	0.96	0.91	1.02	0.92	NC	0.86	0.83	0.83	0.82	0.57	0.57
PCB 448	0.49	0.47	0.46	0.43	0.44	0.52	0.58	0.58	0.59	0.41	0.42
PCB 528	0.51	0.47	0.51	0.47	NC	0.50	0.57	0.56	0.55	0.39	0.39

[a] Represents a single peak of tech. chlordane.

[b] Not calculated; RRF from previous day was used for quantitation.

[c] Represents a single peak in an Aroclor 1254 standard. Webb-McCall peak numbers are given.

[d] Represents a single peak in an Aroclor 1260 standard. Webb-McCall peak numbers are given.

where pg_p is the amount of pesticide injected during instrument calibration and $\bar{A}_p$ is the GC/ECD area response resulting from analysis of standard solutions under the least sensitive conditions. QL values generated using this procedure are listed in Table 32. Since these values are above the linear range, all detected values could be quantitated and the limit of detection is also equal to the QL.

A method QL was calculated assuming a 2 µL injection of a 1 mL sample extract using a total air volume of 4 m^3.

QC Results

Control samples were prepared and analyzed along with field samples for each sampling site. Unspiked PUF plugs served as blanks. PUF plugs spiked with the target pesticides, technical chlordane and Aroclor 1260 (see Table 10) were utilized as controls. For the first two sites, both field and laboratory controls and blanks were processed and analyzed. During subsequent trips, only the field QC sets were utilized. Results of the analysis of field controls and blanks are given in Tables 33 and 34. Percent recovery was calculated as:

$$\% \text{ Recovery} = \frac{ng_{FC} - ng_{FB}}{ng_{spiked}} \times 100\%$$

where -

ng_{FC} is the average amount of target pesticides found on field controls.

ng_{FB} is the average amount of target pesticides found on field blanks; and

ng_{spiked} is the amount of target compound spiked onto field controls.

Recoveries calculated for the earlier trips (elderly home-1 and school) were generally lower and more variable than those calculated for later field monitoring trips. These results could be attributed to several factors:

1) Florisil fractionation was performed on the extracts from the early trips but was not used on later trips;
2) PUF plugs were stored for a longer period of time prior to extraction;
3) sample extracts were stored for a longer period of time prior to analysis; and
4) implementation of the analytical technique may have improved with time.

TABLE 32. QUANTITATION LIMITS (QL) FOR TARGET PESTICIDES AND PCB

Compound	QL (pg injected)	Method QL (ng/m^3)
α-BHC	0.57	0.071
HCB	0.49	0.061
β,γ-BHC[a]	1.21	0.151
Heptachlor	0.67	0.084
trans-Nonachlor	1.07	0.134
Heptachlor Epoxide/Oxychlordane[a]	0.79	0.099
p,*p*'-DDE	0.96	0.120
p,*p*'-DDD	1.26	0.158
p,*p*'-DDT	0.95	0.119
Aroclor 1260	1.84	0.230
tech. Chlordane	1.69	0.211

[a] Compounds coeluted; QL calculated together.

TABLE 33. PERCENT RECOVERY FOR CALCULATED FIELD CONTROL SAMPLES

Compound	% Recovery ± S.D.					
	Elderly home-1	School-1	Office-1	Office-2	Office-3	Elderly home-2[a]
α-BHC	32±32	66±64	34±6	28±22	65±13	84
HCB	45±30	51±34	64±43	NC[b]	90±34	95
β´γ-BHC[c]	42±20	75±90	59±30	NC	95±18	87
Heptachlor	72±47	86±86	110±25	NC	94±18	89
Heptachlor Epoxide/ Oxychlordane[c]	54±19	75±54	52±20	57±25	81±15	72
p,p'-DDE	65±18	70±50	79±29	113	119±20	115
p,p'-DDD	83±6	126±109	127±17	194±70	255±42	218
p,p'-DDT	66±20	26±20	64±61	116±5	124±19	166
Aroclor 1260	14±5	72±14	78±35	85±26	70±10	64
tech. Chlordane	9.3±2.5	47±25	23±25	48±21	63±10	61

[a] Single control valid; FC-2 was contaminated at OCN peak; FC-3 was only spiked with Aroclor 1260.

[b] Not Calculated; high interferences.

[c] Compound coeluted; quantitated together.

TABLE 34. LEVEL OF TARGET PESTICIDES/PCBs FOUND ON FIELD BLANKS

Compound	ng/sample					
	Elderly home-1	School	Office-1	Office-2	Office-3	Elderly home-2
α-BHC	16±16	ND[a]	1.0±0.71	ND	ND	0.94±0.94
HCB	ND	3.1±3.1	ND	ND	ND	ND
β,γ-BHC[b]	ND	ND	ND	ND	ND	ND
Heptachlor	1.4±1.2	ND	ND	5.6±3.9	4.0±4.0	ND
Heptachlor epoxide/ Oxychlordane[b]	1.9±1.9	1.7±1.7	ND	ND	ND	ND
p,p'-DDE	1.0±1.0	ND	ND	ND	ND	ND
p,p'-DDD	ND	ND	ND	ND	ND	ND
p,p'-DDT	1.9±1.9	7.1±8.2	ND	8.7±11	ND	ND
PCBs	14±14	12±14	7.4±7.7	2.9±3.3	7.0±7.4	9.8±2.7
tech. Chlordane	1.2±0	3.4±2.3	7.0±5.9	6.3±3.2	ND	1.3±1.5

[a] Not Detected.

[b] Compounds coeluted; quantitated together.

The reason for the lower recoveries of Aroclor 1260 and technical chlordane from controls for the elderly home-1 are unknown; however, low recoveries were also noted in the laboratory controls for this trip. Generally, very high recoveries were reported for p,p'-DDD. This may have been a chromatographic problem with some other component in the extract decomposing to interfere with p,p'-DDD. There did not appear to be a problem with contamination of field or laboratory blanks.

Sample Analysis

Table 21 shows the number of samples for pesticides/PCBs both collected and analyzed for each field monitoring trip. As described previously, output from the GC/ECD analysis was ng of target pesticide/PCB per PUF plug. This raw mass (ng/plug) was then corrected for background by subtracting mean values for each target (BKG) as determined from field blank cartridges. The mean target values for field control cartridges (spiked with known amounts of each target) allowed for calculation of recovery factors(RF). These were used to correct the background subtracted mass/cartridge values for recovery. Thus, the final, corrected mass determination is calculated as:

$$\text{Total ng} = \frac{\text{ng/plug} - \text{BKG}}{\text{RF}}$$

Since the volume of air sampled for each sample was known and the quantity of substance per cartridge can be determined, the level in ambient air was calculated as:

$$\frac{\text{ng}}{\text{m}^3} = \frac{\text{Total ng}}{\text{Volume Sampled (m}^3\text{)}}$$

Significant problems occurred during the analysis of field samples using packed column GC/ECD analysis. Many of the field samples contained high levels of contaminants which interfered with the analysis of the target pesticides and PCBs. This is illustrated in Figure 15 where the large peaks at 12.6 minutes prevented quantitating p,p'-DDT and PCBs. When this occurred, quantitation of the target pesticides/PCBs was not performed. This resulted in not calculated values for ~20% of the final data base.

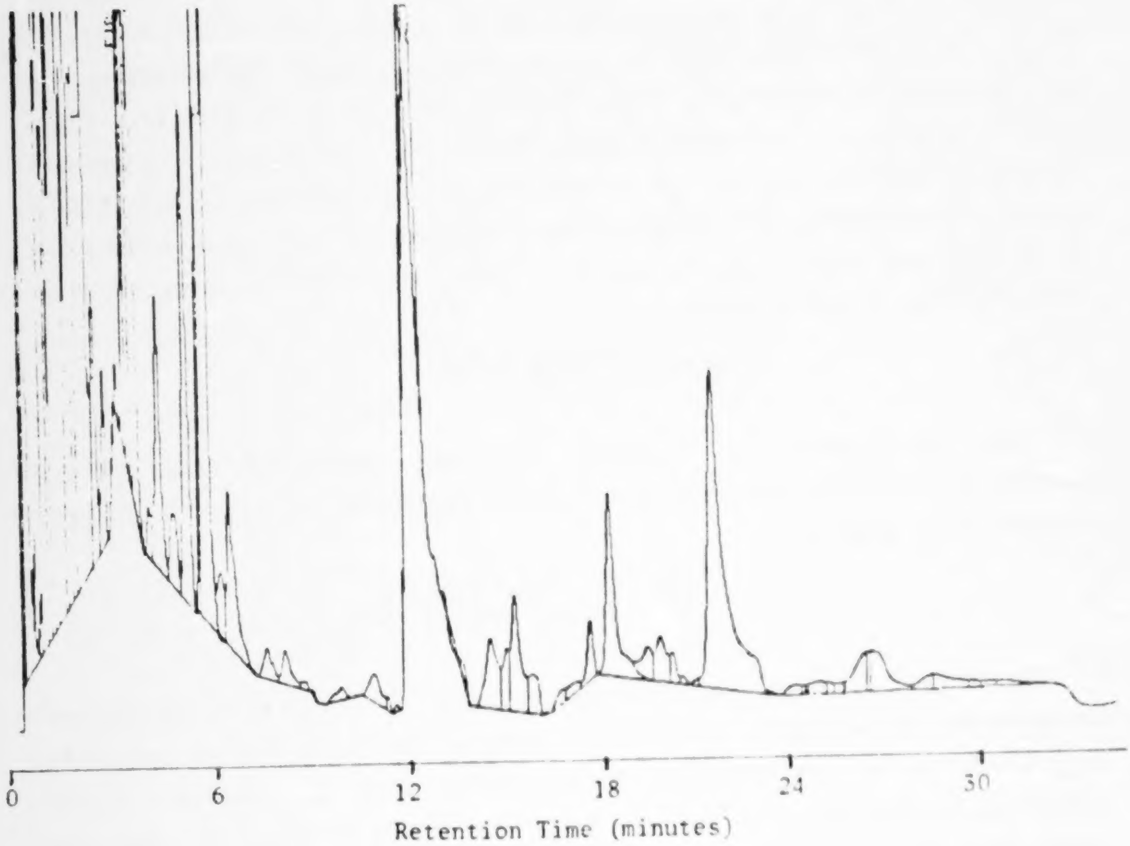

Figure 15. GC/ECD chromatogram of sample extract for the analysis of Pesticides/PCBs.

Fractionation using Florisil chromatography removed few of the interferences. The use of high resolution capillary columns should reduce problems with coeluting sample components to significantly improve the precision, accuracy, and completeness of analytical results. This approach is highly recommended for all future work.

FORMALDEHYDE

Analytical Method

Formaldehyde was recovered from molecular sieve samples by rinsing each sieve sample with 18.5 mL of distilled deionized water for approximately 20 minutes in a glass stoppered 50 mL vial at room temperature. The sieve rinse solution was filtered through Whatman No. 2 paper and collected in a teflon-lined screw cap vial. This solution was reacted with 2.5 mL of acidified pararosaniline reagent (0.16 g pararosaniline + 20 mL HCl diluted to 100 mL with deionized water) with mixing for ~5 minutes. A 250 mL aliquot of sodium sulfate (0.1% in water) was added and the color allowed to develop at 25°C for 75 minutes.

After 75 minutes, the solution was transferred to a cuvette and the absorbance or optical density (O.D.) measured at 570 nm using a Beckman, DU-2 Spectrophotometer. Samples were read against deionized water.

Quantitation was achieved using a formaldehyde calibration curve generated from standards which were prepared at concentrations from .0925 to 3.70 μg/mL and processed at the same time as the samples.

Table 35 lists the standards used to generate the calibration curve. Table 36 characterizes the calibration curves used for sample analysis. Formaldehyde [HCHO] concentration in the rinse solution from each sieve was then calculated as:

$$[\mathrm{HCHO}](\mu\mathrm{g/mL}) = \frac{\mathrm{O.D.} - y_{\mathrm{intercept}}}{\mathrm{slope}}$$

Method Validation

Several recovery studies were performed in order to test the analytical method. First, molecular sieve cartridges were loaded at four different formaldehyde concentrations and analyzed using the modified pararosaniline technique. Table 37 gives test conditions and analytical results. A calibration curve was run each time samples were analyzed. Table 38 shows

TABLE 35. STANDARDS USED TO GENERATE FORMALDEHYDE CALIBRATION CURVE

Standard	Formaldehyde Concentration (μg/mL in deionized water)
1	0
2	0.093
3	0.185
4	0.463
5	0.925
6	1.85
7	2.78
8	3.70

TABLE 36. CHARACTERISTICS OF FORMALDEHYDE CALIBRATION CURVE

Trip	Slope	$y_{intercept}$	r	r^2
Elderly home-1	0.276	-.014	.998	.997
School-1	0.246	-.024	.998	.997
Office-1	SL[a]	SL	SL	SL
Office-2	0.250	-0.17	.998	.997
Office-3	0.231	-.024	.980	.960
Elderly home-2	0.225	-.017	.995	.990

[a] Samples lost due to improper analysis.

TABLE 37. FORMALDEHYDE RECOVERY STUDIES

Amount HCHO Loaded (μg)	Conc. Expected (μg HCHO/mL H_2O)	Concentration Found (μg HCHO/mL H_2O)	% Recovery	No. of Days After Loading Analyses Was Performed
4.63	.23	.23	100	0
		.25	109	0
		.26	113	0
		.18	78	0
		.12	52	0
		.14	61	0
		.17	74	0
5.55	.28	.28	100	0
		.26	93	0
		.26	93	0
		.28	100	0
		.25 [a]	89	0
		.24	86	0
		.27	96	5
		.31	111	5
		.36	128	5
		.33	118	9
		.28	100	9
		.26	93	9
9.25	.46	.41	89	0
		.35	76	0
		.40	87	0
		.46	100	0
		.32	70	0
		.40	87	0
		.51	111	0
18.5	.92	.76	83	0
		.80	87	0
		.92	100	0
		.89	97	0
		.91	99	0
		.95 [a]	103	0
		.92	100	0
		.88	96	5
		.99	108	5
		1.03	112	5
		.83	90	9
		.88	96	9
		.85	92	9

[a] Replicate analyses from the same water rinse solution.

TABLE 38. CALIBRATION CURVE DATA[a] - TRIPLICATE ANALYSIS

Concentration (µg HCHO/mL H_2O)	OD (at 570 nm)	Mean ± SD (CV)
.0625	.028	
	.025	.025 ± .004 (14)
	.021	
.185	.047	
	.044	.046 ± .002 (4)
	.047	
.4625	.110	
	.113	.113 ± .003 (3)
	.116	
.925	.233	
	.234	.235 ± .002 (1)
	.237	
1.85	.486	
	.489	.488 ± .002 (.4)
	.489	
2.78	.774	
	.780	.779 ± .004 (.5)
	.782	
3.70	1.063	
	1.080	1.072 ± .009 (.8)
	1.073	

[a]
r = .999
r^2 = .998
Slope = .287
y_{int} = -.014

reproducibility of the calibration curve when each of the standards was run in triplicate.

In a second experiment, duplicate formaldehyde samples were collected in each of five offices in the Dreyfus building at RTI for ~30 min at 2 L/min (total = ~60 L), to provide an indication of what may be expected in the field. Formaldehyde concentrations ranged from 23 ppb to 720 ppb. Results of the duplicates showed good reproducibility as demonstrated in Table 39.

QC Results

Quality control samples were prepared and analyzed along with field samples for each sampling site. Unspiked sieve served as blank samples and sieve spiked with 18.5 μg of formaldehyde served as control samples. Results of QC analysis are given in Table 40 and 41. Percent recovery was calculated as:

$$\% \text{ Recovery} = \frac{\mu g_{FC} - \mu g_{FB}}{\mu g_{spiked}} \times 100\%$$

where -

μg_{FC} is the average amount of formaldehyde found on field controls.

μg_{FB} is the average amount of formaldehyde found on field blanks; and

μg_{spiked} is the amount of formaldehyde spiked onto the sieve.

Results show generally good recoveries for all field monitoring trips with few problems with background contamination.

Limits of Detection

The instrumental limits of detection (LOD_{OD}) and quantitation limits (QL_{OD}) for formaldehyde analysis were defined as:

$$LOD_{OD} = 2X\ OD_{FB}$$

$$QL_{OD} = 3X\ OD_{FB}$$

where OD_{FB} is the average optical density of the field blank measurements.

These instrumental LOD_{OD} and QL_{OD} values were then converted to method LOD and QL values which were the μg/sieve which could be either detected or quantitated. These parameters were calculated as:

$$LOD_{(\mu g/sieve)} = (LOD_{OD} + Y_{int/slope}) \times \text{volume of eluting solution}$$

$$QL_{(\mu g/sieve)} = (QL_{OD} + Y_{int/slope}) \times \text{volume of eluting solution}$$

these values were then converted to LOD_{ppb} and QL_{ppb} which give method

TABLE 39. RESULTS OF DUPLICATE FORMALDEHYDE ANALYSIS PERFORMED DURING METHOD VALIDATION

Sampling Location at RTI	Formaldehyde Concentration (ppb)
1	750 680
2	21 25
3	48 44
4	139 133
5	67 63

TABLE 40. AMOUNT OF FORMALDEHYDE FOUND ON FIELD BLANKS

Trip	Formaldehyde Level (μg)	
	FB[a] (N)[b]	LB[c]
Elderly home-1	2.46(3)	3.04(3)
School	5.68(3)	6.20(3)
Office-1	SL[d]	SL
Office-2	2.48(2)	2.08(2)
Office-3	2.20(3)	2.08(4)
Elderly home-2	9.42(4)	5.24(4)

[a] Field blank.

[b] Number of blanks analyzed.

[c] Laboratory blank.

[d] All samples from Office-1 trip lost.

TABLE 41. % RECOVERY OF FORMALDEHYDE FROM CONTROL SAMPLES

Trip	% Recovery ± S.D.	
	FC[a]	LC[c]
Elderly home-1	93 ± 4(3)	95 ± 6(3)
School	60 ± 3(3)	71 ± 8(3)
Office-1	SL[d]	SL
Office-2	93 ± 1(2)	90 ± 1(2)
Office-3	78 ± 31(3)	66 ± 31(4)
Elderly home-2	78 ± 14(4)	107 ± 7(4)

[a] Field control.

[b] Number of controls analyzed.

[c] Laboratory control.

[d] All samples from Office-1 lost.

detection and quantitation limits in terms of formaldehyde concentration in air, where:

$$\mathrm{LOD} = \frac{\mathrm{LOD}_{\mu g/sieve} - \mathrm{BKG}_{\mu g/sieve}}{\text{sample volume } (m^3)} \times 1.22\ m^3/kg$$

$\mathrm{Bkg}_{\mu g/sieve}$ is the average amount of formaldehyde found on field blanks (see Table 40) and 1.22 m^3/kg is a constant used to convert m^3 of air into weight assuming 50% relative humidity under standard temperature and pressure conditions. LOD and QL values calculated for each field monitoring trip are given in Table 42.

Sample Analysis

Table 21 shows the number of sieve samples collected and analyzed for each field monitoring trip. Results of the pararosaniline analysis gave μg of formaldehyde per sieve. This raw mass (μg/sieve) was then corrected for background by subtracting the average amount of formaldehyde found on field blanks ($[HCOH]_{FB}$). The mean amount of formaldehyde found on field control sieve allowed for calculation of recovery factors. These were used to correct the background subtracted mass/cartridge values for recovery. The final corrected mass determination was calculated as:

$$\text{Total } \mu g = \frac{(\mu g/\text{sieve}) - [HCOH]_{FB}}{RF}$$

Since the volume of air sampled to produce a given sample was known, formaldehyde concentration in ppb in air was calculated as:

$$[HCHO]_{ppb} = \frac{\text{total } \mu g / 1.22\ m^3/kg}{\text{sample volume } (m^3)}$$

where -

1.22 m^3/kg is the factor used to convert m^3 of air into kg weight assuming 50% relative humidity at standard temperature and pressure conditions.

INHALABLE AND RESPIRABLE PARTICULATES

Analytical Method

Filters used for sampling inhalable and respirable particulates with the Dichotomous sampler were weighed by EPA (EMSL-RTP) before and after exposure.

TABLE 42. LIMITS OF DETECTION AND QUANTITATION LIMITS FOR FORMALDEHYDE ANALYSIS

	LOD			QL		
Trip	OD	µg/sieve	ppb[a]	OD	µg/sieve	ppb
Elderly home-1	.040	3.92	~20	.060	5.36	~32
School	.092	9.40	~50	.038	13.20	~70
Office-1	SL[b]	SL	SL	SL	SL	SL
Office-2	.028	3.60	~15	.042	4.72	~30
Office-3	.002	2.20	~15	.003	2.34	~15
Elderly home-2	.180	17.42	~100	.270	25.4	~150

[a] Exact LOD depends upon the volume collected for each field sample.

[b] All samples from Office-1 trip lost.

Filters used for sampling inhalable and respirable particulates using the NBS samplers were weighed at Research Triangle Institute before and after exposure. Filters were weighed using a Mettler Balance (Serial No. 650272) with certified accuracy to 0.001 mg. Filters were equilibrated at 70±1°C and 50±2% relative humidity before weighing. All filters were exposed to an ionizing source immediately prior to weighing to reduce the static charge and improve reproducibility of filter weights. Results of filter weights were reported to the nearest μg.

QC Results

Unexposed filters were set aside to serve as blanks for each sampling trip. For each trip, one-half of the blank filters were sent to the field to serve as field blanks while the other half remained in the laboratory. All blanks were weighed before and after sampling at the same time as field samples. No control samples were available. Data for blank samples are given in Table 43.

Limits of Detection

No limits of detection or quantifiable limits were defined for either the samples weighed by RTI or the samples weighed by EPA. A particulate concentration was reported for all samples.

Sample Analysis

Table 21 shows the number of samples for inhalable and respirable particulates collected and analyzed for each field monitoring trip.

Particulate concentration in air samples was calculated as:

$$[\text{Particulate}]\ \text{mg/m}^3 = \frac{FW_{AE} - FW_{BE} - FB}{\text{Volume of air sampled (m}^3\text{)}}$$

where -

FW_{BE} is the filter weight before exposure.

FW_{AE} is the filter weight after exposure.

FB is the average amount of particulate found on the blank filters.

During the second trip to the office building, the weight determination of filters before exposure was not performed properly; therefore, a weight differential and particulate concentration could not be determined for any of the samples collected during this trip.

TABLE 43. RESULTS OF ANALYSIS OF BLANK FILTERS FOR RESPIRABLE PARTICULATE

Trip	Weight Difference[a] (mg) ± SD
Elderly home-1	0.008 ± 0.005
School	NC[b]
Office-1	0.002 ± 0.001
Office-2	SL[c]
Office-3	0.023 ± 0.007[d] 0.015 ± 0.010[e]
Elderly home-2	0.010 ± 0.005[d] 0[e]

---

[a] Weight difference = $(\text{weight})_{BM} - (\text{weight})_{AM}$ where $(\text{weight})_{BM}$ and $(\text{weight})_{AM}$ are the weights of the same blank sample taken before and after field monitoring.

[b] Not collected as specified in the Work Plan.

[c] All samples lost from the second trip to the office.

[d] Coarse particulate filter.

[e] Fine particulate filter.

ELEMENTS

Analytical Method

Filters collected for element determinations were sent to Florida State University for analysis by proton induced X-ray emission (PIXE) spectrometry. Analysis was performed for the elements listed in Table 44. Types and numbers of samples analyzed from each trip are described in Table 45.

QC Results

At the elderly home-1 and the school where the streakers were used for sample collection, portions of the filter remained unexposed to serve as field blanks. During analysis, metal concentrations were determined for five of the unexposed segments on the filters. For the remaining field monitoring effort, unexposed filters served as field and laboratory blanks. Only the field blanks were analyzed. Results of the analysis of blank filters are given in Tables 46 to 48.

Limits of Detection (LOD)

Instrumental limits of detection were generated by Florida State University during analysis of each set of samples. These data are given in Table 49. Instrumental limit of detection is a function of irradiation time. Filters from the office and the school were irradiated for a shorter time period than filters from the elderly home-1, and hence have higher LODs by approximately two orders of magnitude. However, since large samples were collected at these sites, approximately the same final concentration in air could be detected for all samples.

Estimated method LODs were calculated from the results of field blank measurements. For the metals which were detected in the field blanks, method LOD were calculated as LOD = $\bar{X}$+2 S.D. where $\bar{X}$ is the average amount of the element found on the blank and S.D. is the calculated standard deviation of the measurement. Where elements were not detected on field blanks, the method LOD was identical to the instrumental LOD.

For sampling sites where streakers were used (i.e., the elderly home-1 and the school), method LODs were calculated for each filter analyzed. Then the highest calculated LOD on any of filters from one site was used as the method LOD for that field sampling site. For the remaining sampling sites (i.e., the office and the elderly home-2), results of all

TABLE 44. ELEMENTS ANALYZED BY PIXE ANALYSIS

- Sodium
- Magnesium
- Aluminum
- Silicon
- Phosphorous
- Chlorine
- Potassium
- Calcium
- Scandium
- Titanium
- Vanadium
- Chromium
- Manganese
- Sulfur
- Molybdenum[a,b]
- Cobalt
- Nickel
- Copper
- Zinc
- Arsenic
- Bromine
- Strontium[a]
- Selenium
- Rubidium[a]
- Cadmium[a]
- Mercury[a]
- Lead
- Iron
- Zirconium

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[a] Not analyzed on filters exposed at the elderly home-1.

[b] Not analyzed on filters exposed at the school.

TABLE 45. ELEMENTAL ANALYSIS PERFORMED FOR EACH SAMPLING TRIP

Location	Filter Type	Time Resolution (hr)	No. of Analyses/Site	No. of Sites	Total Number of Analyses[a]
Elderly home-1	Mylar	1	72	6	432
	Nucleopore	1	72	6	432
School	Mylar	4	18	4	72
	Nucleopore	4	18	4	72
Office-1	Nucleopore	24	2	6	12
Office-2	Nucleopore	24	2	6	12
Office-3	Nucleopore	24	2	6	12
Elderly home-2	Nucleopore	24	3	5	15

[a] Each analysis performed by PIXE for 26 elements.

TABLE 46. ELEMENTS FOUND ON FIELD BLANKS (STREAKER) - ELDERLY HOME-1

Element	Amount ± S.D./(ng/filter)							
	Coarse Particulate Filter							
	1F	2F	2D	3F	4F	5F	6F	6D
Na	ND[a]	ND	ND	ND	ND	ND	ND	ND
Mg	1.7±1.7	ND	1.0±1.5	ND	ND	ND	1.1±1.5	1.3±1.8
Al	3.7±0.95	4.0±1.1	2.3±2.2	4.3±1.0	3.7±2.1	3.75±0.40	4.2±0.65	4.0±0.47
Si	ND	ND	ND	0.25±0.52	ND	ND	ND	ND
P	ND	ND	ND	ND	ND	ND	ND	ND
S	1.5±0.34	1.3±0.73	1.3±0.76	1.8±0.32	1.2±0.73	1.5±0.45	1.4±0.84	1.7±0.4
Cl	0.92±0.53	0.70±0.68	0.91±0.89	1.3±0.23	0.24±0.55	1.05±0.63	0.79±0.74	3.0±3.5
K	ND	0.15±0.34	ND	0.30±0.42	ND	0.16±0.35	ND	0.15±0.33
Ca	ND	ND	ND	0.11±0.25	ND	ND	ND	ND
Sc	ND	ND	ND	ND	ND	ND	ND	ND
Tl	ND	ND	ND	ND	ND	ND	ND	ND
V	ND	ND	ND	ND	ND	ND	ND	ND
Cr	0.22±0.21	0.09±0.19	0.16±0.22	0.34±0.20	0.33±0.21	0.14±0.23	0.21±0.20	0.44±0.09
Mn	ND	ND	ND	ND	0.07±0.15	ND	ND	ND
Fe	0.40±0.10	0.35±0.20	0.30±0.19	0.39±0.09	0.42±0.12	0.43±0.10	0.40±0.09	0.36±0.06
Co	ND	0.02±0.05	ND	ND	ND	ND	ND	ND
Ni	0.06±0.09	0.04±0.06	0.05±0.07	0.06±0.08	0.05±0.07	ND	0.32±0.67	ND
Cu	ND	ND	0.02±0.04	0.05±0.07	0.03±0.06	0.03±0.07	0.07±0.11	0.02±0.05
Zn	ND	ND	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND	ND	ND
Se	ND	ND	ND	ND	ND	ND	ND	ND
Br	ND	ND	ND	0.07±0.16	ND	ND	ND	0.02±0.04

(continued)

TABLE 46. (cont'd.)

Element	Amount ± S.D./(ng filter)						
	Fine Particulate Filter						
	1F	1D	2F	4F	5F	6F	6D
Na	ND	ND	ND	ND	ND	ND	ND
Mg	0.42±0.44	1.3±0.86	0.31±0.70	ND	ND	ND	0.36±0.80
Al	1.23±0.80	1.7±1.4	1.35±1.14	0.86±1.2	1.42±1.4	1.8±1.1	0.99±1.4
Si	ND	ND	ND	0.24±0.53	ND	ND	0.94±1.3
P	6.9±1.0	ND	8.1±0.48	7.2±0.52	8.21±0.77	8.1±0.5	8.1±0.99
S	ND	0.63±0.59	ND	ND	ND	ND	ND
Cl	ND	0.79±0.14	ND	ND	0.18±0.41	ND	0.49±1.1
K	ND	0.11±0.25	ND	ND	0.14±0.32	ND	1.4±3.1
Ca	0.55±0.33	ND	0.14±0.32	0.30±0.41	0.23±0.31	0.54±0.53	0.30±0.41
Sc	ND	ND	ND	ND	ND	ND	ND
Tl	ND	ND	ND	ND	ND	ND	ND
V	ND	ND	ND	0.07±0.15	ND	ND	ND
Cr	0.05±0.12	ND	ND	ND	ND	ND	ND
Mn	ND	0.08±0.11	0.05±0.12	ND	ND	ND	ND
Fe	0.13±0.12	0.03±0.08	0.09±0.21	ND	ND	0.08±0.18	0.06±0.13
Co	ND	ND	ND	ND	ND	0.03±0.06	ND
Ni	0.01±0.03	ND	ND	0.02±0.05	ND	0.02±0.05	ND
Cu	0.08±0.12	0.11±0.10	0.06±0.09	0.09±0.13	0.06±0.09	0.09±0.09	0.08±0.08
Zn	0.94±0.73	ND	0.87±0.06	0.89±0.20	0.85±0.09	0.73±0.43	0.83±0.14
As	ND	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND	ND
Se	ND	ND	ND	0.05±0.11	0.10±0.13	0.02±0.05	0.05±0.11
Br	ND	ND	ND	0.07±0.17	ND	ND	ND

---

[a] Below the instrumental limit of detection.

TABLE 47. ELEMENTS FOUND ON FIELD BLANKS (STREAKER) - SCHOOL

	Amount ± S.D./(ng filter)				
	Coarse Particulate Filter				
Element	F1	F2	D2	F3	F4
Na	7.4±9.5	1.3±12	21±3.6	12±11	18±10
Mg	31±7.4	38±3.5	41±2.8	38±7.6	42±7.4
Al	30±6.2	37±4.6	39±6.0	35±7.5	34±8.7
Si	3.3±7.3	10±6	9.8±9.0	9.3±9.4	6.0±8.5
P	ND[a]	ND	ND	ND	ND
S	14±0.7	16±2	16±2.4	18±2.5	19±2.2
Cl	10±1.3	76±38	9.2±2.0	9.6±1.0	34±38
K	ND	ND	ND	ND	5.2±12
Ca	ND	0.58±1.5	ND	1.7±1.6	0.66±1.5
Sc	0.70±1.2	ND	ND	1.6±2.0	ND
Ti	0.20±0.45	0.42±0.95	ND	1.5±1.0	0.64±0.94
V	ND	ND	ND	0.62±0.86	0.32±0.82
Cr	1.7±1.0	0.32±0.71	0.78±1.1	1.3±0.82	1.3±1.8
Mn	ND	ND	ND	ND	ND
Fe	2.5±0.88	3.1±0.41	2.8±0.59	3.0±0.60	2.6±0.58
Co	ND	ND	ND	ND	.14±3.2
Ni	0.61±0.35	0.70±0.34	0.84±0.51	0.81±0.12	.33±.28
Cu	0.53±0.36	0.49±0.41	0.68±0.11	0.76±0.26	.39±.32
Zn	ND	ND	ND	ND	ND
As	0.73±0.54	0.47±3.9	0.67±0.59	0.53±0.50	.57±.33
Br	0.23±0.52	0.27±0.61	ND	0.36±0.55	ND
Sr	ND	ND	ND	ND	ND
Se	0.46±0.65	0.54±0.46	1.15±0.23	0.48±0.68	.42±.34
Rb	ND	ND	ND	ND	ND
Cd	8.27±7.1	ND	2.3±5.1	0.28±0.61	ND
Hg	0.67±1.5	ND	ND	0.97±1.39	0.66±1.5
Pb	ND	ND	ND	ND	ND

(continued)

TABLE 47. (cont'd.)

	Amount ± S.D./(ng/filter)				
	Fine Particulate Filter				
Element	F1	F2	D2	F3	F4
Na	27±28	19±2.8	17±40	15±7.4	17±3.4
Mg	17±2.3	26±6.7	21±3.3	23±10	23±3.0
Al	14±3.3	20±4.6	14±2.5	17±5.8	17±2.9
Si	ND	1.8±0.41	1.1±0.24	1.6±3.7	ND
P	ND	ND	ND	ND	ND
S	6.4±2.1	6.7±1.4	8.1±0.62	6.0±1.8	3.6±2.2
Cl	8.0±1.4	9.1±2.4	7.8±1.8	6.6±1.4	5.9±2.4
K	1.5±1.4	ND	ND	ND	1.6±3.6
Ca	1.4±2.0	1.2±1.2	ND	ND	1.0±1.5
Sc	0.27±0.60	0.64±0.88	ND	0.24±0.52	ND
Ti	1.02±1.07	0.79±0.76	ND	ND	0.27±0.61
V	0.26±0.58	ND	ND	0.22±0.49	ND
Cr	ND	ND	ND	ND	ND
Mn	ND	ND	ND	ND	ND
Fe	0.56±0.55	0.26±0.32	ND	0.22±0.30	1.5±2.8
Co	1.10±0.22	ND	0.09±0.21	ND	ND
Ni	0.22±0.32	0.25±0.18	0.22±0.21	0.34±0.27	1.7±2.5
Cu	0.09±0.20	0.13±0.19	0.11±0.24	0.38±0.28	1.8±2.4
Zn	0.02±0.05	ND	ND	ND	ND
As	0.08±0.02	0.22±0.30	0.12±0.26	0.40±0.30	1.8±4.0
Br	ND	ND	ND	ND	ND
Sr	ND	ND	ND	ND	ND
Se	0.48±0.43	0.42±0.27	0.40±0.37	ND	1.4±3.1
Rb	ND	ND	ND	0.33±0.74	0.32±0.72
Cd	ND	0.30±0.41	ND	ND	ND
Hg	ND	ND	0.76±1.04	0.45±0.86	ND
Pb	ND	ND	ND	ND	ND

[a] Below the instrumental limit of detection.

TABLE 48. ELEMENTS FOUND ON FIELD BLANKS[a]

	ng/filter			
Element	Office-1	Office-2	Office-3	Elderly home-2
Na	33	280	ND[b]	ND
Mg	65	680	400	370
Al	590	610	460	470
Si	190	240	54	ND
P	ND	ND	ND	ND
S	240	240	260	270
Cl	210	220	640	1200
K	ND	ND	ND	ND
Ca	ND	ND	ND	ND
Ti	ND	ND	ND	ND
V	ND	13	ND	ND
Cr	23	52	57	53
Mn	ND	ND	ND	ND
Fe	53	98	53	75
Ni	22	180	22	17
Cu	17	62	ND	9
Zn	ND	ND	ND	ND
As	34	87	23	35
Sc	33	26	69	13
Br	ND	ND	ND	23
Sr	ND	ND	ND	ND
Zn	NC[b]	ND	ND	ND
Mo	NC	ND	1050	680
Cd	ND	ND	ND	ND
Hg	ND	50	41	ND
Pb	ND	ND	ND	ND
Sc	ND	23	NC	NC
Co	ND	ND	NC	NC[c]
Rb	ND	ND	NC	NC

---

[a] Duplicate determinations.

[b] Not Detected.

[c] Not Calculated; no analysis performed.

TABLE 49. INSTRUMENTAL LIMITS OF DETECTION FOR PIXE ANALYSIS

	LOD (ng/filter)				
	Elderly home-1		School		Office-1,2,3
Element	C[a]	F[b]	C	F	Elderly home-2
Na	1.7	1.4	8.5	7.0	129
Mg	1.2	1.1	6.5	5.2	106
Al	1.2	1.1	6.2	4.9	112
Si	1.4	0.88	5.1	3.9	93
P	0.95	0.90	4.5	3.3	81
S	0.94	0.81	4.5	3.2	82
Cl	0.85	0.75	4.1	3.0	70
K	0.72	0.59	3.4	2.4	66
Ca	0.59	0.51	2.8	2.0	57
Sc	0.51	0.45	2.4	1.7	31
Ti	0.43	0.36	2.0	1.4	42
V	0.37	0.32	1.7	1.2	37
Cr	0.30	0.26	1.4	0.96	31
Mn	0.25	0.21	1.2	0.82	26
Fe	0.20	0.17	0.87	0.62	21
Co	0.17	0.12	0.66	0.45	9.4
Ni	0.14	0.10	0.44	0.37	13
Cu	0.14	0.10	0.46	0.43	17
Zn	0.12	0.12	0.36	0.33	18
As	0.22	0.19	0.48	0.62	28
Pb	0.77	0.67	2.7	2.3	93
Se	0.24	0.24	0.65	0.54	33
Br	0.30	0.31	1.2	0.09	44
Sr	NA[c]	NA	2.1	1.6	81
Rb	NA	NA	1.3	1.4	34
Cd	NA	NA	1.1	7.4	201
Hg	NA	NA	2.0	2.4	84
Zr	NA	NA	NA	NA	128
Mo	NA	NA	NA	NA	15

[a] Coarse particulate filter - streaker.

[b] Fine particulate filter - streaker

[c] Not analyzed.

field blank analyses were combined to determine a method LOD. Calculated method LODs are given in Table 50. Quantifiable limits (QL) were defined as four times the LOD. Values for QL are listed in Table 51.

Method LODs and QLs were much higher for the school than for elderly home-1 since there were higher levels of contamination on filter blanks.

Sample Analysis

Table 21 shows the number of filter samples collected and analyzed for elements for each field monitoring trip. Results of PIXE analyses gave ng per filter for up to 29 elements per filter. This mass was then compared to the method QL for that field monitoring trip. If the mass on the filter was greater than the QL, then that mass was directly converted to the concentration in air ($\mu g/m^3$) by dividing by the sample volume, where

$$\text{Concentration } (ng/m^3) = ng/\text{sampling volume } (m^3)$$

No adjustments in final concentration were made to account for background contamination or recovery from the filters during analysis.

AIR EXCHANGE

Analytical Method

Air samples which had been collected and stored in plastic syringes were analyzed by GC/ECD to quantitate sulfur hexafluoride (SF_6) concentrations. Conditions for GC analysis are given in Table 52. Whenever samples were analyzed, a calibration curve was first generated to confirm instrumental linearity using SF_6 concentrations ranging from 200 ppt to 100 ppb. Each day of analysis, a standard prepared at 100 ppb was analyzed to demonstrate instrument stability. If the instrument response for SF_6 had changed by greater than 15%, a new calibration curve to verify linearity was generated. SF_6 in samples was quantitated using manually measured peak heights. All of the samples collected from one site during a single sampling period (one SF_6 release) were analyzed as a group to minimize errors due to changes in instrumental response. Air exchange rates (ACH) were calculated as:

$$ACH = \frac{1}{t} \ln P_i/P_o$$

where P_i is the chromatographic peak height of SF_6 at time t, and
P_o is the initial peak height of SF_6.

TABLE 50. METHOD LIMITS OF DETECTION (LOD) FOR ELEMENTAL ANALYSIS

Element	LOD (ng/filter)				
	Elderly home-1		School		Office--1,2,3
	C[a]	F[b]	C[a]	F[b]	Elderly home-2
Na	1.7	1.7	30	40	450
Mg	3.1	5.1	43	53	820
Al	4.2	7.8	29	51	700
Si	3.5	1.4	10	39	340
P	10	0.95	2.7	4.7	81
S	1.8	3.1	11	23	690
Cl	2.6	2.7	11	13	2100
K	0.78	81.1	8.8	2.8	66
Ca	1.60	0.61	5.3	4.8	57
Sc	0.51	0.51	2.4	5.6	83
Ti	0.43	0.43	3.2	3.6	42
V	0.37	0.37	1.4	2.3	37
Cr	0.30	0.82	0.82	4.9	79
Mn	0.30	0.37	0.70	1.2	25
Fe	0.51	0.75	1.7	4.3	150
Co	0.17	0.14	0.55	0.79	9.4
Ni	0.14	0.19	0.85	1.9	34
Cu	0.55	0.29	0.94	1.3	24
Zn	1.59	0.12	0.12	0.12	18
As	0.22	0.22	1.1	1.9	61
Pb	0.77	0.77	1.9	0.95	93
Se	0.37	0.24	1.3	1.8	88
Br	0.40	0.40	0.81	1.5	44
Sr	NA[c]	NA	2.0	1.8	81
Rb	NA	NA	1.81	1.5	34
Cd	NA	NA	11	23	200
Hg	NA	NA	2.9	3.8	94
Zr	NA	NA	NA	NA	130
Mo	NA	NA	NA	NA	2410

[a] Coarse particulate filter - streaker.

[b] Fine particulate filter - streaker.

[c] Not analyzed.

TABLE 51. METHOD QUANTIFIABLE LIMITS (QL) FOR ELEMENTAL ANALYSIS

Element	QL (ng/filter)				
	Elderly home-1		School		Office-1,2,3 Elderly home-2
	C[a]	F[b]	C[a]	F[b]	
Na	6.8	6.8	120	160	1800
Mg	12	20	170	210	3200
Al	17	31	120	200	2800
Si	14	5.6	40	160	1400
P	40	3.8	11	19	320
S	7.2	12	44	92	2800
Cl	10	11	44	52	8200
K	3.1	4.4	35	11	264
Ca	6.4	2.4	21	19	230
Sc	2.0	2.0	9.2	22	330
Ti	1.7	1.7	13	14	170
V	1.5	1.5	5.6	9.2	150
Cr	1.2	3.3	3.3	20	320
Mn	1.2	1.5	2.8	4.8	100
Fe	2.0	3.0	6.8	17	600
Co	0.68	0.56	2.2	3.2	38
Ni	0.56	0.72	3.4	7.6	140
Cu	2.2	1.2	3.8	5.2	96
Zn	6.4	0.48	0.48	0.48	72
As	0.88	0.88	4.4	7.6	240
Pb	3.1	3.1	7.6	3.8	370
Se	1.5	0.92	5.2	7.2	350
Br	1.6	1.6	3.2	6.0	170
Sr	NA[c]	NA	8.0	7.2	324
Rb	NA	NA	7.2	6.0	140
Cd	NA	NA	44	92	800
Hg	NA	NA	12	11	380
Zr	NA	NA	NA	NA	510
Mo	NA	NA	NA	NA	9600

[a] Coarse particulate filter - streaker.

[b] Fine particulate filter - streaker.

[c] Not analyzed.

TABLE 52. GC/ECD OPERATING CONDITIONS FOR QUANTITATIVE ANALYSIS OF SF_6

Parameter	Specification
Column	2.50 m x 2.1 mm i.d. stainless steel Chromosorb 102, 80/100 mesh
Nitrogen carrier flow	20.0 mL/min
Temperatures:	
Valve/sample loop	unheated
Injector	80°C
Column	50°C (isothermal)
Detector	75°C
Sample loop	1.00 mL volume, stainless steel
Make-up gas	None
Detector type	Variable current Sc ^3H ECD
Pulse width	4 µS @ 40 v
Pulse interval	1000 µS

Method Validation

Several aspects of the procedure for measuring air exchange rate using sulfur hexafluoride (SF_6) as the tracer gas were studied prior to sample collection and analysis. The gas chromatographic system was tested first. Two column packings were evaluated: molecular sieve 5Å and Chromosorb 102. Both packings were 80/100 mesh and packed in 8 ft x 2.1 mm I.D. stainless steel columns. Using a column temperature of 50°C, SF_6 and O_2 coeluted using the molecular sieve packing, but were separated (~2 minutes) using the Chromosorb 102 packing. The optimum gas chromatographic conditions tested are those shown in Table 52.

The linear range of the instrument was established next. Using a cubical Lucite chamber with mixing provided by a magnetic stirrer, an initial concentration of 100 ppb of SF_6 in air was prepared. Triplicate analyses for SF_6 were made at this point; the chamber was then exponentially diluted at a rate to provide one "air change" in 26.8 min. A sample was taken at appropriate intervals and analyzed in triplicate to provide a calibration curve which was linear from 200 ppt to 100 ppb. Lower concentrations were not sampled and analyzed due to the effect of trace impurities in air as well as the effect of the O_2 peak on the SF_6 peak at these levels.

Once the linearity of the detector was established, a simple study for the release and collection of SF_6 into a building was performed. Using Dreyfus Auditorium at RTI, which is a circular one-room structure with a volume of approximately 18,000 cubic feet, the method could be easily tested. Using instantaneous release of SF_6, a syringe sample was simultaneously started to collect air samples. The collection sequence is shown in Table 53. The subsequent analyses of the air samples showed the expected exponential decay of the SF_6 levels in air once the initial mixing stage (ca. 0.4 h) was complete. A graph of the results is shown in Figure 16. From this data, the air exchange rate (ACH, number of exchanges per hour) was determined to be 1.11.

LIMITS OF DETECTION

As stated above, the limit of detection for SF_6 in air samples was ~200 ppt.

TABLE 53. COLLECTION SEQUENCE OF AIR SAMPLES USING A SYRINGE-TYPE AIR SAMPLER

Syringe No.	Start Time	End Time	Minutes Collected	Mean Time (hours)
1	0:00[a]	0:06	6	0.05
2	0:06	0:12	6	0.15
3	0:12	0:18	6	0.25
4	0:18	0:24	6	0.35
5	0:24	0:30	6	0.45
6	0:30	0:36	6	0.55
7	0:36	0:48	12	0.70
8	0:48	1:00	12	0.90
9	1:00	1:12	12	1.10
10	1:12	1:36	24	1.40
11	1:36	2:00	24	1.80
12	2:00	2:24	24	2.20

[a] This is simultaneous with release of the tracer gas.

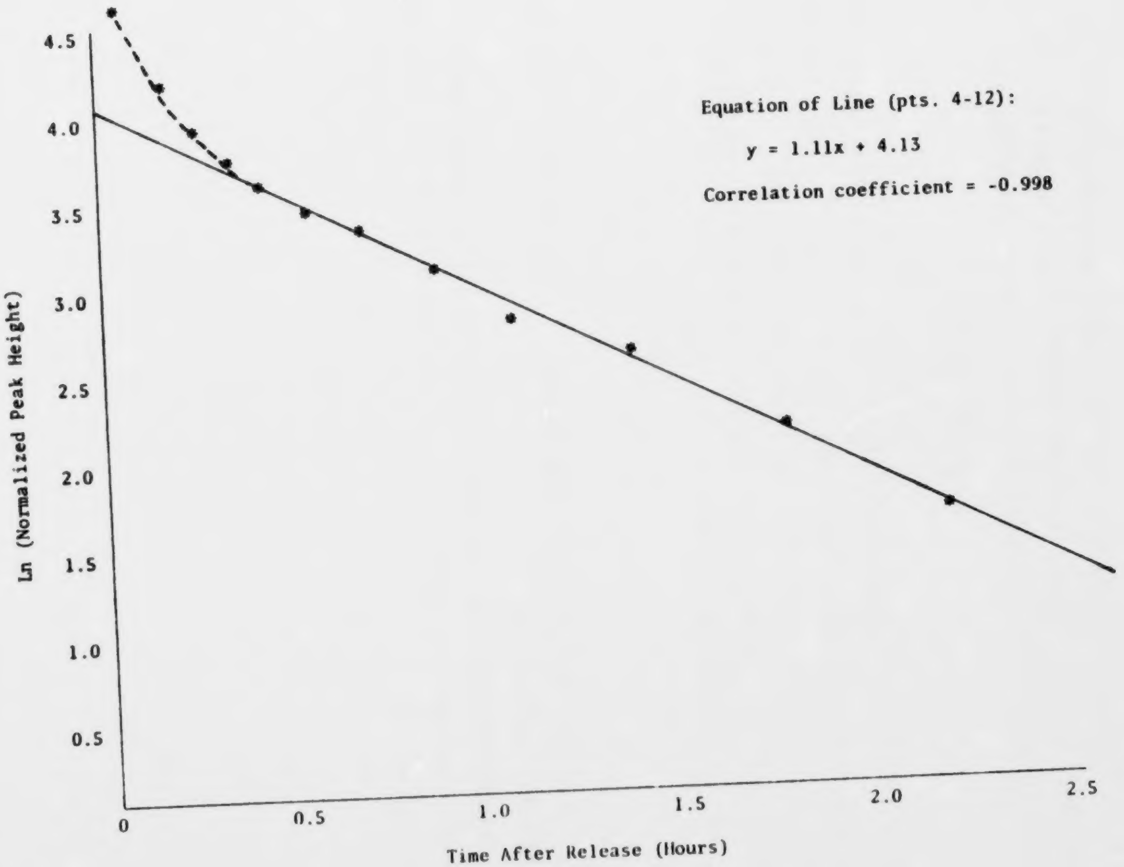


Figure 16. Exchange rate of air in Dreyfus Auditorium.

QC Results

No QC samples were prepared or analyzed during exchange rate determination.

Sample Analyses

Table 21 shows the number of samples both collected and analyzed during each field monitoring trip.

The GC/ECD analysis of air samples gave chromatographic peak heights for air sampled at a specific time after SF_6 release into the building. Infiltration rates at each sampling location are calculated as:

$$\frac{v}{V} = \frac{1}{t} \ln(C_i/C_o)$$

where v/V is the air infiltration rate in units of air changes/hr, C_i is the tracer concentration at time, t, and C_0 is the initial trace concentration. Since only the relative concentration of SF_6 (C_1/C_0) is required and since the SF_6 concentration is directly proportional to peak height, the air infiltration can be calculated as:

$$\frac{v}{V} = \frac{1}{t} \ln (P_i/P_o)$$

where P_i is the chromatographic peak height of SF_6 at time t and P_0 is the initial peak height of SF_6.

A computer program was written to calculate exchange rates from peak height and sampling time information. An example of the data output is given in Figure 17.

```
Sample Code:        INAIR 311-1 AE-3F

RESULTS             Analyzed:  1-12-84

Syringe  Pk. Ht.              Pk. Ht.                      Mean Time     Mean Time
  No.     (cm)     Attn.   (cm @ 1X)    ln (Pk. Ht.)    (hrs.)       X Ln(Ht)     Time 2       (Ln)^2
                                    -----------------------------------     ---------    ---------    ---------
-----------------------------------------------------
   1      17.60     128     2252.8          7.720          .1          .7719929     .0100000     59.59731

   3      18.70      64     1196.8          7.087          .5          3.543703     .2500000     50.23133

   5      20.10      32      643.2          6.466          .9          5.819810     .8100000     41.81505

   7      23.30      16      372.8          5.921         1.3          7.697355     1.690000     35.05874

   9      15.10      16      241.6          5.487         1.7          9.328382     2.890000     30.11028

  11      16.30      16      260.8          5.564         2.1          11.68388     4.410000     30.95536
-----------------------------------------------------------------------     ---------    ---------    ---------

Equation of Line:  y =     -1.15190 x  +   7.641
                         [ln (Pk. Ht.) vs/ Time]                          .4666667     .6628263

Correlation Coefficient:    -.966540

Exchange Rate (1/hr):       1.151904 (Neg. Slope of Line)
```

Figure 17. Field analysis protocol sheet - Indoor air study.

SECTION 7

SOURCES OF VOLATILE CHEMICALS

INTRODUCTION

Results from the field monitoring effort clearly showed the presence of elevated levels of several volatile organics in public buildings, in particular, in the newly constructed office building. A comparison of indoor-outdoor levels indicated ratios greater than an order of magnitude occurred and decreased with time as the building "aged". For some chemicals, however, levels increased with time. These observations suggested that different sources accounted for the trends in the chemical levels, some perhaps from the building materials used in construction, others from the consumer products employed as the building became occupied.

To assess source contribution which might have been responsible for these observations, an inventory of various building materials was compiled and consumer products used were noted. From these listings of materials, materials were selected for a headspace screening of volatile organic chemicals emitted, and those materials which emitted the target chemicals found in the monitoring study were then selected for an emission rate study. This section discusses the headspace screening and emission rate studies conducted to support the results obtained for the new office building.

HEADSPACE SCREENING OF EMISSIONS FROM MATERIALS

The objective of this study was to identify, if possible, the materials responsible for the high levels of volatile organics found indoors in the new office building. Materials of interest were obtained from the contractor who constructed the building, portions of the actual materials used were acquired.

Procedure

The building materials and consumer products tested are shown in Table 54, together with their uses. Portions of these materials were placed in 250 mL clean glass vessels fitted with septum top screw-caps. Liquid materials occupied approximately 10-20% of the total volume of the vessel. Solid materials occupied 30-50% of the volume of the vessel. The glass vessels were placed in an oven at 45°C for a period of 2-3 hrs to allow for equilibration of volatile organics, if any, from each of the materials.

Gas chromatography/mass spectrometry (GC/MS) was employed for the analysis of the headspace vapors above each of these materials.

A 1 liter gas bulb equipped with two teflon stopcocks was purged with helium for 10 min at 30°C. Subsequently, the stopcocks were closed and a known amount of perfluorotoluene (PFT) was injected through a septum into the glass bulb. The liquid aliquot injected was usually 0.5 to 0.8 mL. The PFT was allowed to equilibrate for 30 min at 30°C while being stirred with a teflon coated magnetic stirring bar before gaseous aliquots of PFT were withdrawn.

One mL of gaseous PFT was pulled into a 10 mL Pressure Lok syringe and then 1-5 mL of headspace of the sample was also drawn into the syringe. Prior to injection approximately 2-3 in of the fused silica capillary column was submerged in liquid nitrogen for 3 min with the GC door open and the temperature held at 30°C. After 3 min the sample was injected onto the GC column, GC/MS data acquisition started and 2 min after injection and the column was removed from the liquid nitrogen cryogenic bath, the GC door was closed and the temperature program was begun. A 60 m DB-1 coated fused silica capillary (1 micron film thickness) was programmed from 30°C to 240° at 4°/min.

Qualitative interpretation of mass spectra obtained from the headspace analysis was performed. This involved employing a GC/MS operator interactive INCOS search software routine to compare acquired or unknown spectra with those found in the NBS/NIH/EPA library.

TABLE 54. BUILDING MATERIALS AND CONSUMER PRODUCTS SCREENED

Material	Use
Armstrong Fissured Minaboard Ceiling	Accoustical ceiling tile
FICAM-W	Insecticide
Carpet glue	-
Carpet	-
Sheetrock	-
Borden E8825 film	Wallpaper glue
650	Cleaning Compound
PT-110	Insecticide
Talon-G	Rodenticide
Old Dutch Cleanser	Cleaning compound
Seventy-seven	Synthetic detergent
PT-250	Insecticide
Stainless steel polish and cleaner	Cleaning compound
Brillo	Window cleaning
Lemon Speedway Wax	Furniture polish

Results and Discussion

Figures B-1 to B-19 in Appendix B and Tables C-1 to C-18 in Appendix C present the chemicals identified in each of the headspace samples. Table C-1 and C-17 present the organics which were found in a blank or empty vessel. A few background peaks were observed at very low intensity which were attributed to the background from the septum employed and hydrocarbons from the laboratory air. Chemicals originating as background were deleted in the samples containing building materials or consumer products except where the levels were extremely high (> 10 times).

Table C-2 presents the organics found in the headspace of Talon-G. As indicated from this listing, a number of hydrocarbons were detected as well as a few aldehydes, furans and ketones. Table C-3 presents the volatile organics found associated with the Armstrong fissured minaboard ceiling. Most of the chemicals were hydrocarbons. In addition to hydrocarbons, oxygenated and halogenated hydrocarbons were identified in the headspace of the remaining materials.

Since the PFT external standard was included during headspace analysis, the relative levels of TEAM indoor target compounds to PFT were determined and are presented in Tables D-1 to D-18 (Appendix D). Even though the cross section of ionization, and thus the MS response factor, differs from chemical to chemical, it is useful to compare the relative amounts of volatile organics within a sample and to some extent the relative amounts between samples.

Upon examining the headspace results for various materials, only small quantities of the target chemicals were found in Armstrong fissured minaboard ceiling, carpet, Borden E8825 film, and seventy-seven. On the other hand, the remaining materials had trace to substantial quantities of target chemicals. In particular very high levels of 1,1,1-trichloroethane were detected in PT-250.

Based on the higher relative levels found, materials were selected for an emission rate study.

EMISSION RATE DETERMINATION

In collaboration with the Pierce Foundation at Yale University (New Haven, CN), an environmental chamber was employed to determine emission rates for various targeted volatile organics from building materials and consumer products. Several of these chemicals also occurred at relatively high levels (relative to ambient levels) in the newly constructed office building.

Materials

The materials selected for the environmental chamber study included wallpaper, painted sheetrock, carpets and various cleaning agents. Air samples were collected using the Tenax GC sampling method. Samples were collected within the environmental chamber, approximately 1 m from the floor.

Eleven 1.98 m x 1.22 m panels of sheetrock were painted on each side with Glidden Spread Undercoat No. 555 white to provide a total of 22 surfaces and aged for 1 week prior to beginning the chamber experiment. Eleven 1.98 m x 1.22 m panels of sheetrock were covered with locally purchased textured wallpaper to provide 22 covered surfaces. Borden E8825 film was used to glue the wallpaper to the sheetrock. Six 1.98 m x 1.22 m wood panels were carpeted on each side to provide 12 carpeted surfaces and also aged for 1 week. Glue employed in the newly constructed office building was supplied to the Pierce Foundation staff and used to adhere the carpet to the wood panels.

Environmental Chamber

Tenax GC sampling of the various materials took place in a 1200 cu ft. (34 m^3) environmental chamber. A schematic view of the chamber is given in Figure 18. Internal surfaces and duct work of the chamber were constructed of aluminum. The floor (11 m^2) consisted of uniformly perforated aluminum sheets overlayed with an aluminum grating. The perforated floor served as an air diffuser. Air entered the chamber via a plenum beneath the floor and flowed linearly upward through the perforations into the ceiling plenum. Circulation rate of the chamber can be varied by varying the amount of fresh air brought into the chamber. Determination of the recirculation rate was accomplished by monitoring the removal of CO_2 injected into the chamber. A Beckman Model LB-2 infrared CO_2 analyzer was used to monitor the CO_2 decay.

Sampling

Materials (except cleansing agents) were placed inside the chamber not less than 12 hrs before sampling. A constant recirculation rate was maintained at all times. The 1.98 m x 1.22 m panels were placed in an

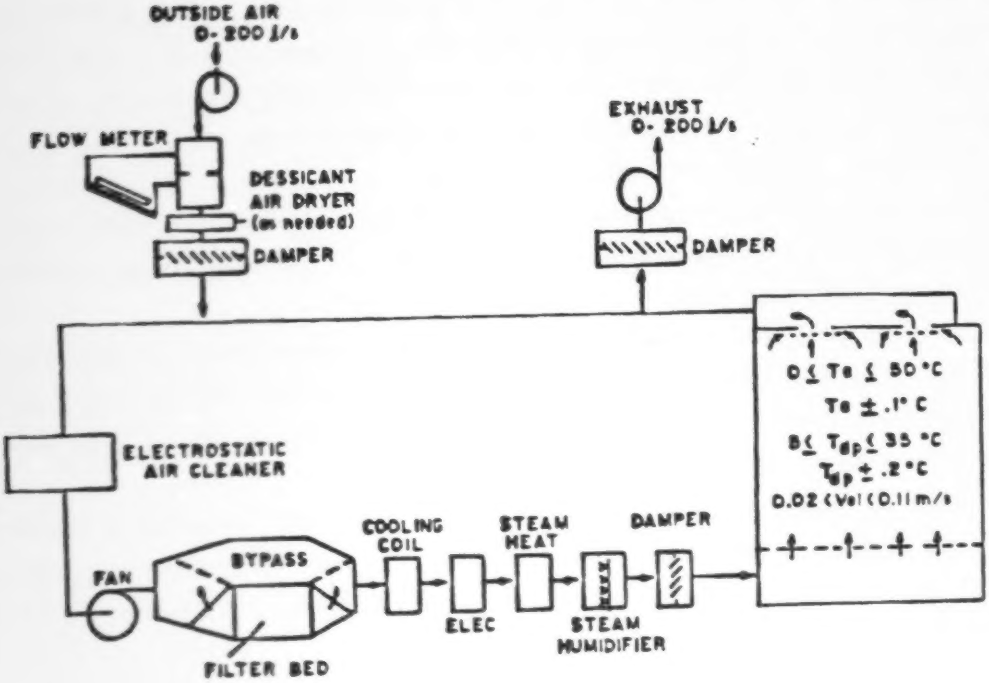

OUTSIDE AIR
0-200 l/s
FLOW METER
DESSICANT
AIR DRYER
(as needed)
DAMPER
EXHAUST
0-200 l/s
DAMPER
0 ≤ Ta ≤ 50 °C
Ta ± .1° C
5 ≤ Tdp ≤ 35 °C
Tdp ± .2 °C
0.02 < Vel < 0.11 m/s
ELECTROSTATIC
AIR CLEANER
FAN
BYPASS
FILTER BED
COOLING
COIL
ELEC
STEAM
HEAT
STEAM
HUMIDIFIER
DAMPER

Figure 18. Schematic of environmental chamber used in emission study.

upright lengthwise position in the chamber and were spaced 23 cm from any adjacent panel so all surfaces received maximum exposure. For the experimen t that utilized the cleaning agents, various surface areas were employed. Two wood table tops each with a surface area of 0.91 m x 0.91 m were placed in the chamber. A wood folding table with a surface area of 1.4 m x 0.87 m was used and a wood two-tier rolling cart with each tier having a surface area of 1.19 m x 0.58 m was also replaced in the chamber.

Six Tenax samplers were used for every experiment. Three of the six samplers were placed inside the chamber while the remaining three samplers were placed on a bench adjacent to the chamber. The samplers were oriented to hang unobstructed about 1.07 m over the floor.

Table 55 presents a summary of sampling conditions. In general, for each of the experiments the relative humidity was 60-75% with an air exchange rate of ~ 0.60 ACH. The sampling time was ~ 4 hrs with an average pump flow rate of 80 mL/min.

Table 56 presents the time breakdown for the experiment involving cleaning agents. At each time period, an activity was initiated and completed so that several materials were exposed simultaneously in the environmental chamber.

Results and Discussion

Table 57 presents the levels of volatile organics that were observed for each of the experiments. The average background of these volatiles organics was monitored in an empty chamber and then substracted from the observed values for each of the four experiments that was conducted.

For the sheetrock that was painted with Glidden paint and aged for 1 week prior to conducting the experiment in the environmental chamber, emissions of four chemicals were detected above the background levels. n-Undecane exhibited a concentration of 228 $\mu g/m^3$. Benzene was also detected (18 $\mu g/m^3$).

Small amounts of volatile organics were also detected above background levels in the wall-papered sheetrock experiments. Again the two hydrocarbons, n-decane and n-undecane were both present. No benzene was detected in this case.

TABLE 55. SUMMARY OF SAMPLING CONDITIONS

Experiment	Date	Material	Chamber Temp.	Chamber RH	Vent Rate	Sample Time	Average Pump Flow	Volume Air Sampled	Chamber Sampler Code	Control Sampler Code
I	7/26/84	Empty chamber (blank)	25°C	60%	0.62 ACH	240 min	80 mL/min	19.2 L	A1 B1 C1	D1 E1 F1
II	7/27/84	Sheetrock	25.5°C	65%	0.59 ACH	240 min	80 mL/min	19.2 L	A2 B2 C2	D2 E2 F2
III	8/1/84	Wallpaper	25°C	75%	0.61 ACH	240 min	80 mL/min	19.2 L	A3 B3 C3	D3 E3 F3
IV	8/2/84	Cleaning agents	26.5°C	75%	0.60 ACH	255min	80 mL/min	20.4 L	A4 B4 C4	D4 E4 F4
V	8/7/84	Rugs	25°C	70%	0.60 ACH	240 min	80 mL/min	19.2 L	A5 B5 C5	D5 E5 F5

TABLE 56. TIME BREAKDOWN OF EXPERIMENT IV (CLEANING AGENTS)

Elapsed Time	Activity
0 min	Start samplers
15 min	Wash 1/3 of each surface with Brillo
105 min	Wash 1/3 of each surface with seventy-7; spray wallboard[a] with Baygon (6 times; 2 sec. each spray)
145 min	Wash the remaining 1/3 of each surface with BAB-O
255 min	Stop samplers

TABLE 57. LEVELS OF VOLATILE ORGANICS FROM SOURCES

Chemical	Empty Chamber	Chamber Air Concentration ($\mu g/m^3$)			
		Sheetrock	Wallpaper	Cleaning Agents	Carpet
Chloroform	4.3 ± 2.8(64)	ND	ND	283 ± 5(1.7)[a]	ND
1,2-Dichloroethane	4.2 ± 0.7(16)	ND	48 ± 7.3(15)	236	15 ± 1(7)
1,1,1-Trichloroethane	0.25 ± 0.5(25)	4.9 ± 2.3(47)	13 ± 7.6(59)	696 ± 295(42)[a]	22 ± 2.6(12)
Benzene	25 ± 1.7(7)	18 ± 4.5(25)	ND	ND	ND
Carbon tetrachloride	0.5 ± 0.4(80)	ND	ND	1335 ± 100(7.5)[a]	ND
Trichloroethylene	5.7 ± 1.4(25)	ND	ND	7 ± 2.6(3.8)	ND
Tetrachloroethylene	8.5 ± 3.6(41)	ND	ND	ND	ND
Chlorobenzene	0.12 ± 0.07(58)	ND	ND	ND	ND
Ethylbenzene	3.6 ± 2.3(65)	ND	ND	ND	6.4 ± 3.2(51)
p-Xylene	11 ± 5.4(50)	ND	4 ± 1(25)	ND	13 ± 2.1(16)
Styrene	2.9 ± 3.4(120)	ND	ND	ND	8.4 ± 1.2(15)
o-Xylene	5.6 ± 4.7(84)	ND	1 ± .5(50)	ND	8.5 ± 2.3(27)
m-Dichlorobenzene	3.8 ± 2.3(62)	ND	ND	10.5 ± 0.5(3.6)	ND
p-Dichlorobenzene	4.2 ± 1.2(29)	ND	ND	8.4 ± 0.1(1.2)	3.5 ± 1.2(36)
n-Decane	4.3 ± 1.3(31)	38 ± 4.5(12)	30 ± 12(40)	3.2 ± 0.5(16)	46 ± 13(28)
o-Dichlorobenzene	0.13 ± 0.15(115)	ND	ND	ND	ND
n-Undecane	5.4 ± 1.2(23)	228 ± 54(24)	47 ± 17(36)	21 ± 0(0)	42 ± 12(30)

[a] Data corrected for chamber background.

The highest concentrations of chemicals were found when the cleaning agents and an insecticide had been applied to surfaces. High levels of chloroform, 1,2-dichloroethane, 1,1,1-trichloroethane, and carbon tetrachloride were observed as well as lower quantities of dichlorobenzenes.

To calculate an emission rate from the observed concentrations we assume complete mixing and equilibrium:

$$C_\infty - C_0 = S/V_a$$

where C_∞ is the equilibrium concentration ($\mu g/m^3$), C_0 is the background concentration in the chamber, S is the source emission rate ($\mu g/hr$), V is the volume of the chamber (m^3) and is the air exchange rate/hr.

Table 58 presents the emission rates observed from the various selected sources. The values are presented in $ng/min/m^2$. These data clearly suggest that many of the volatile organics may originate from various cleaning agents that are employed. The high levels of 1,1,1-trichloroethane are consistent with the previously observed high values in the new office building. Also, the higher indoor air levels of other halogenated chemicals observed in the new office building may be attributed to the similar sources with high emission rates. The trend towards higher concentrations of volatile organics in daytime samples would point to consumer products rather than building materials as the source of the chemicals. This trend is notable since air exchange rates in the buildings are lowest at night. If a steady source was present, this would cause elevated concentrations of organic chemicals during overnight sampling.

TABLE 58. EMISSION RATES FROM VARIOUS SELECTED SOURCES

Chemical	Emission Rate (ng/min/m^2)			
	Cleaning Agents and **Insecticides**	Painted Sheetrock	Glued Wallpaper	Glued Carpet
Chloroform	15,000±250 (1.5)[a]	ND[b]	ND	ND
1,2-Dichloroethane	12,000	ND	310±46 (15)	180±12 (7)
1,1,1-Trichloroethane	37,000±15,000 (42)	31±15 (47)	84±48 (57)	260±31 (12)
Benzene	ND	120±29 (25)	ND	ND
Carbon tetrachloride	71,000±5,300 (7.5)	ND	ND	ND
Trichloroethylene	370±47 (3.8)	ND	ND	ND
Tetrachloroethylene	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	77±39 (50)
Ethylbenzene	ND	ND	ND	150±24 (16)
p-Xylene	ND	ND	26±6.5 (25)	98±14 (15)
Styrene	ND	ND	ND	98±26 (27)
o-Xylene	ND	ND	6.5±3.1 (50)	ND
m-Dichlorobenzene	560±20 (3.6)	ND	ND	41±14 (36)
p-Dichlorobenzene	440±5 (1.2)	ND	ND	545±150 (28)
n-Decane	170±27 (16)	240±29 (12)	190±77 (40)	ND
o-Dichlorobenzene	ND	ND	ND	500±150 (30)
n-Undecane	1,100±0 (0)	1500±350 (24)	300±110 (36)	

[a] Coefficient of variance (%), N = 3 observations. ±SD (CV), N = 3 observations.

[b] ND = not detected (values are in ng/min/m^2).

SECTION 8
RESULTS

VOLATILE ORGANICS

Identification of Volatile Organics in Indoor/Outdoor Samples

In collaboration with the EPA Project Officer, sixteen indoor and outdoor air samples (Table 59) collected during field monitoring were selected for full qualitative characterization of volatile organics. Reconstructed ion current chromatograms for the selected samples are given in Figures 19-22. The external standard (ES), perfluorotoluene, is marked on each chromatogram. Since the same amount (150 ng) of external standard was added to all cartridges, analytical results may be normalized using peak height of this standard. Component identifications were performed by searching the EPA/NIH database using an interactive operator - Incos computer search algorithm. Results of the qualitative interpretation are summarized in Table 60 separating chemicals by chemical class. Listings of straight and branched chain aliphatic hydrocarbons are not given since these compounds were ubiquitous and identification of specific isomers is not possible without authentic standards. Specific isomer identifications for the aromatic hydrocarbons were not made for the same reasons. For other chemical classes, isomer identifications are given, however these identifications are only tentative, based on the best fit of the deconvoluted spectra with the database spectrum.

Alphatic hydrocarbons, such as the decanes, undecanes, and dodecanes, are the most abundant class in all samples, both in terms of the frequency of detection and concentration.

Statistical Analysis

Several types of statistical analysis were performed on the data for volatile organics collected during this indoor air study. For the initial analysis, the percentage of air samples with measurable concentrations

TABLE 59. AIR SAMPLES FOR QUALITATIVE ANALYSIS

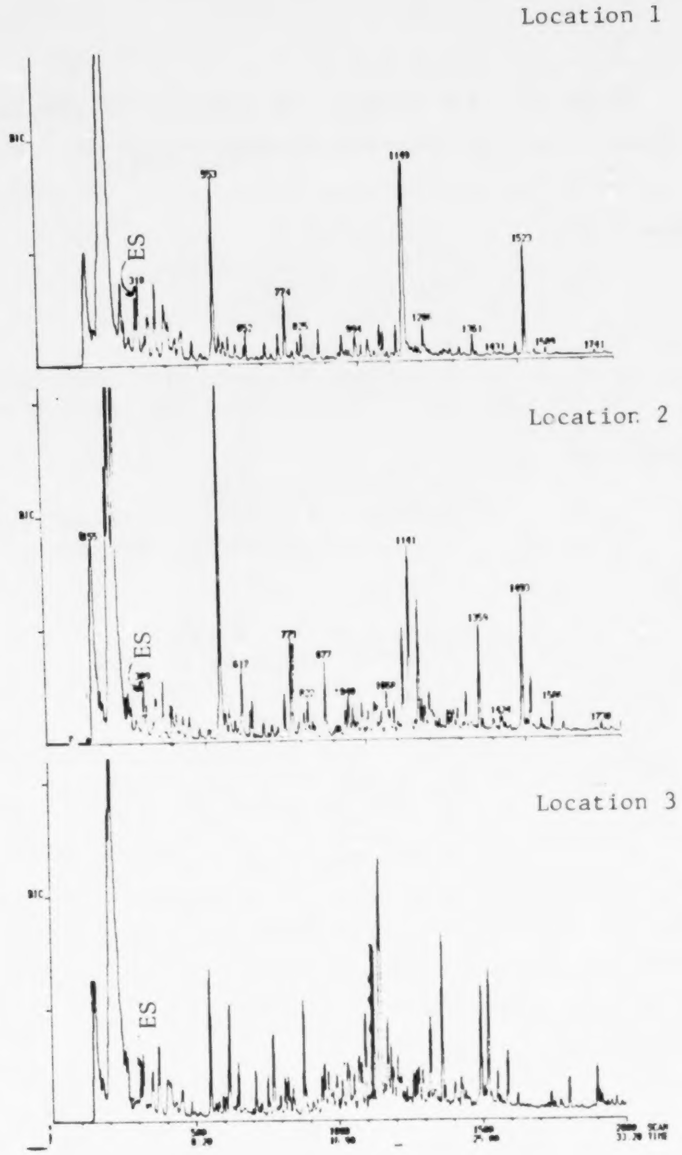
Location	Description
Elderly Home - 1[a]	
1	outside at air intake
2	5th floor lounge
3	3rd floor lounge - smoking
4	dining room
5	1st floor occupied apartment (nonsmoker)
6	1st floor occupied apartment (somker)
Elderly Home - 2[b]	
1	outside at air intake
2	3rd floor occupied apartment (nonsmoker)
3	5th floor unoccupied apartment
Office - 1[c]	
1	outside at air intake
2	2nd floor secretarial area
3	3rd floor copier room
4	2nd floor office
School[d]	
1	outside at air intake
2	2nd floor
3	ground floor

[a] Elderly home-1; samples collected 3/83.

[b] Elderly home-2; samples collected 12/83.

[c] Office, trip - 1; samples collected 8/83.

[d] School, samples collected 5/83.

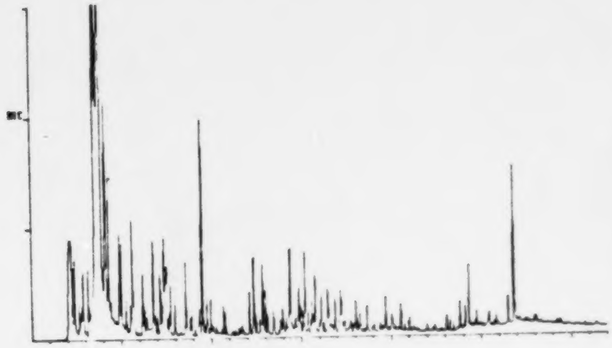

Location 1

Location 2

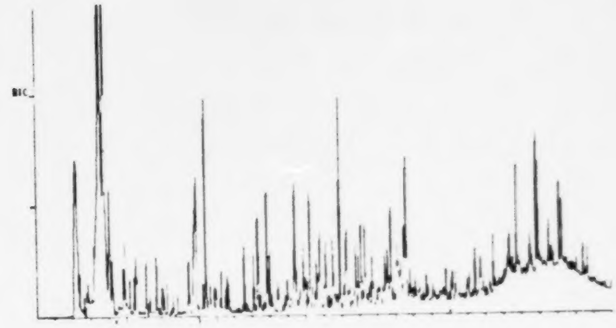
Location 3

Figure 19. Reconstructed ion chromatograms of air samples collected at Elderly home-1; ES = 150 ng of pentafluorotoluene. (See Table 59 for location identifications).

Location 1



Location 2



Location 3

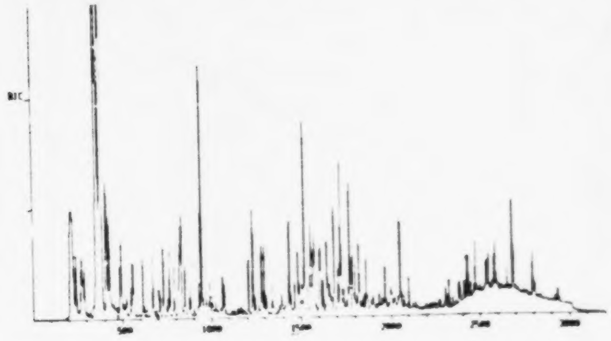
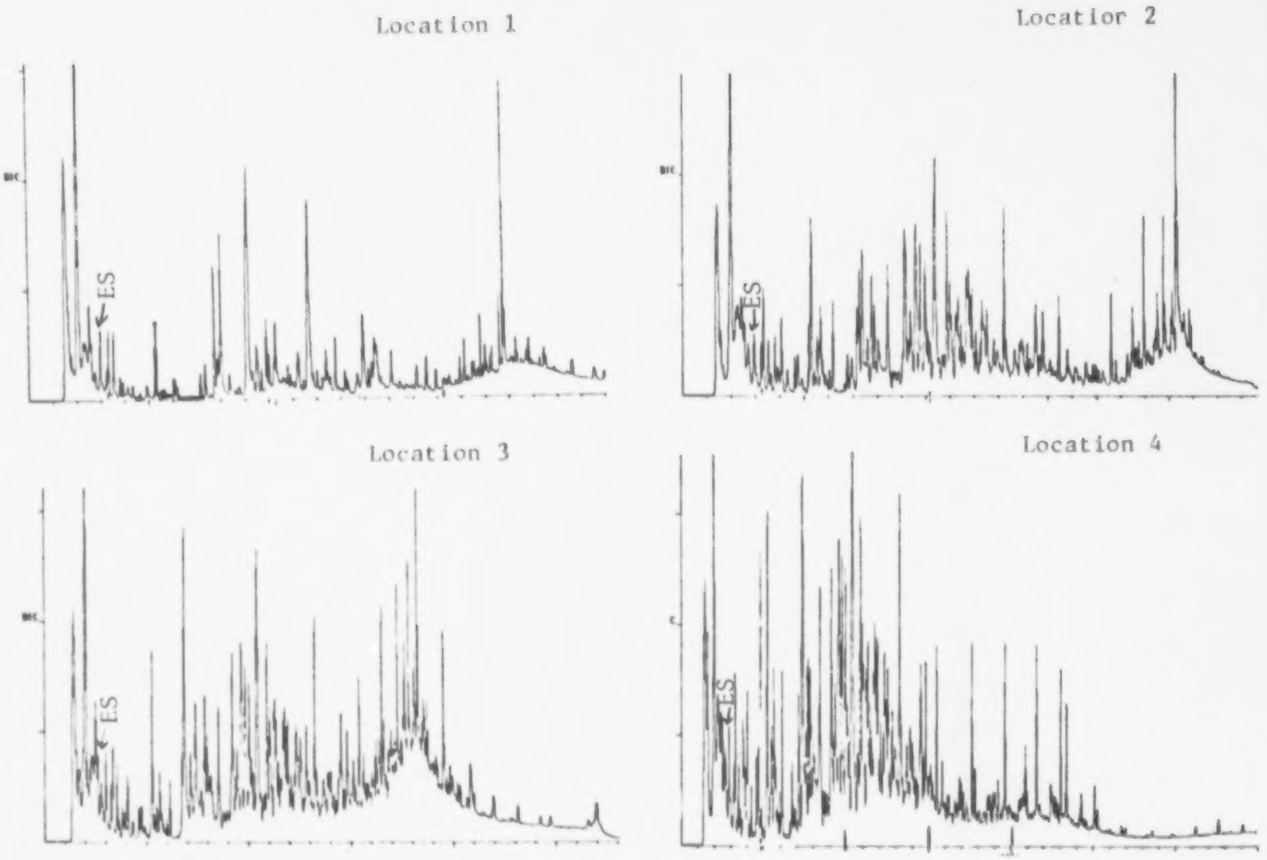


Figure 20. Reconstructed ion chromatograms of air samples collected at Elderly home-2; ES = ∿150 ng of pentafluorotoluene. (See Table 59 for location identifications).


Location 1

Location 2

Location 3

Location 4

Figure 21. Reconstructed chromatograms of air samples collected at office-1; ES = ~150 ng pentafluorotoluene (See Table 59 for location identifications).

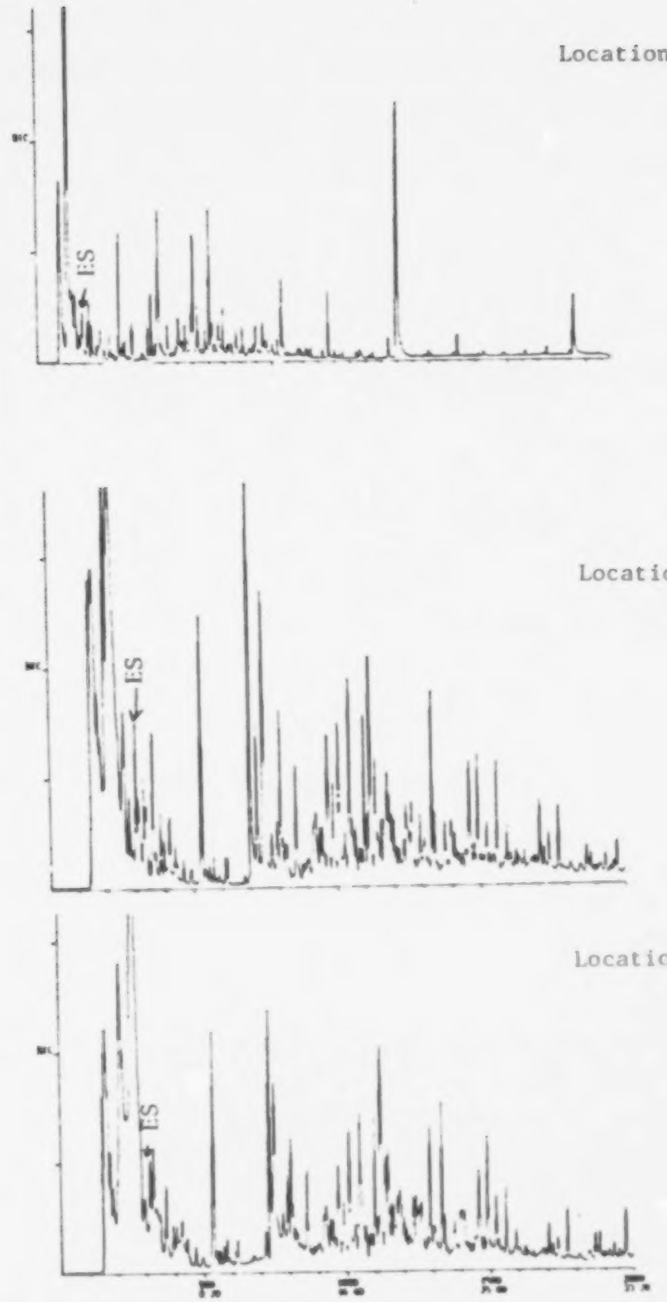


Figure 22. Reconstructed ion chromatograms of air samples collected at the school; ES = ∿150 ng of pentafluorotoluene. (See Table 59 for location identifications).

TABLE 60. ORGANIC COMPOUNDS IDENTIFIED DURING SELECTED AIR SAMPLE[a]

Compounds	Elderly Home-1						Elderly Home-2			Office-1				School			Total Times Identified
	1	2	3	4	5	6	1	2	3	1	2	3	4	1	2	3	
Aromatic Hydrocarbons																	
benzene	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
toluene	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
m,p-xylene	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
o-xylene	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
styrene	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
ethyl benzene	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
phenyl acetylene	X										X		X				3
isopropyl benzene	X	X	X	X	X	X									X	X	8
n-propyl benzene	X	X	X	X	X	X		X			X	X	X	X	X	X	13
ethyl methyl benzenes	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
trimethyl benzenes	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
indene								X									1
2-methyl phenyl acetylene		X								X							2
sec-butylbenzene								X			X						2
t-butylbenzene								X			X		X				3
propylmethylbenzenes	X			X	X	X	X	X	X	X	X	X	X	X	X	X	14
dimethylethylbenzenes	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	15
diethyl benzenes	X	X	X	X	X		X			X	X	X	X	X		X	12
tetramethyl benzenes						X	X	X	X	X		X			X	X	8
ethenyl ethyl benzene							X	X	X	X	X	X			X		7
methyl propenyl benzene							X	X	X			X					4
diethenyl benzene									X	X							2
naphthalene	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	15
methyl indane	X														X		2
pentyl benzenes	X	X					X		X			X	X	X	X		8
dimethyl propyl benzene				X	X	X									X		4
pentamethyl benzene						X											1
ethyltrimethyl benzenes	X							X		X					X		4
ethylpropyl benzenes										X				X			2
methylbutenyl benzene		X		X													2
methyl naphthalenes	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	15
methyl dihydronaphthalene						X				X							2
methyl tetralines	X	X			X	X									X		5
dimethyl indans	X									X					X		3
(3,3-dimethylbutyl)benzene													X				1
methy-2-(ethylpropyl)benzene																	0
hexamethyl benzene						X											1
triethyl benzenes						X		X		X					X		4
diisopropyl benzene										X							1
diethyldimethyl benzene										X							1
dimethyl(methylpropyl)benzene										X							1
cyclohexenyl benzene				X						X	X						3
butenyldimethyl benzene						X									X		2
trimethyl(methylethenyl)benzene															X		1
di(methylethenyl)benzene											X						1
dimethyl naphthalenes						X		X	X			X		X	X	X	7
ethyl naphthalene														X	X		2
di(methylethenyl)benzene											X						1
dimethyl tetralins										X							1
ethyl tetralins						X				X							2
biphenyl						X			X	X		X	X				5
trimethyl naphthalene								X									1
ethylphenyl benzene										X							1
butylhexyl benzene													X				1

(continued)

TABLE 60 (continued)

Compounds	Elderly Home-1						Elderly Home-2			Office-1				School			Total Times Identified
	1	2	3	4	5	6	1	2	3	1	2	3	4	1	2	3	
Halogenated Hydrocarbons																	
chloromethane	X		X	X		X	X								X		6
dichloromethane	X	X	X	X	X	X	X	X	X	X					X		11
chloroform					X	X	X	X	X	X	X	X		X		X	10
carbon tetrachloride		X					X		X	X	X	X		X		X	8
trichlorofluoromethane	X	X	X	X	X	X	X	X	X					X	X	X	12
dichlorodifluoromethane							X	X	X								3
dichlorofluoromethane									X								1
1,1,1-trichloroethane	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	15
trichloroethylene	X	X	X	X	X	X		X	X	X	X	X	X	X		X	14
tetrachloroethylene	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
1,2-dichloroethane							X		X					X			3
vinylidene chloride				X		X											2
1,1,2-trichloro-1,2,2-trifluoroethane	X		X				X		X								4
1,1-dibromo-2-chloro-2-fluorocyclopropane										X							1
chlorobenzene							X		X	X		X		X		X	6
m-dichlorobenzene	X	X	X	X	X	X	X		X		X	X		X	X	X	13
p-dichlorobenzene	X	X	X	X	X	X	X		X	X		X		X		X	12
o-dichlorobenzene		X		X		X	X	X	X	X		X	X	X		X	11
trichlorobenzene		X			X												2
3-chloro-1-phenyl-2-butene												X					1
Esters																	
ethyl formate								X									1
1-methylethyl formate											X						1
n-butyl formate													X				1
ethyl acetate	X	X	X	X	X	X					X		X				8
2-propyl acetate													X				1
butyl acetate								X									1
diethyl acetate							X	X							X		3
3-methyl-1-butyl acetate								X									1
1-phenyl acetate								X									1
n-hexyl acetate									X								1
n-decyl acetate									X								1
o-ethylmethylbenzene acetate										X							1
n-pentylbutanoate								X									1
1-methylethyl butanoate								X							X		2
n-hexyl butanoate											X	X		X		X	4
methylbutyl benzoate								X									1
dimethyl phthalate										X							1
diethyl phthalate										X							1
dibutyl phthalate										X							1
Alcohols																	
ethanol									X								1
2-nitroethanol								X									1
2-propanol		X					X						X				3
2-methoxyethanol							X										1
1,2-propanediol									X								1
n-butanol			X		X			X									3
cyclobutanol	X																1
1,2-butanediol							X										1
n-pentanol										X			X				2

(continued)

TABLE 60 (continued)

Compounds	Elderly Home-1						Elderly Home-2			Office-1				School			Total Times Identified
	1	2	3	4	5	6	1	2	3	1	2	3	4	1	2	3	
Alcohols (cont'd.)																	
4-penten-2-ol											X						1
n-hexanol	X	X	X	X	X	X	X				X						8
2-cyclohexene-1-ol	X			X													2
2-methylpentanol									X								1
2-ethylbutanol														X			1
3-methylpentanol															X		1
2-(1,1-dimethylethoxy)-ethanol			X	X													2
2-butoxyethanol				X									X				2
n-heptanol			X	X					X								3
5-methylhexanol						X											1
3-methylhexanol								X									1
2,2-dimethyl-1-pentanol															X		1
1-methyl-2-cyclohexene-1-ol				X													1
3-methylcyclohexanol										X			X				2
2-ethyl-4-methyl-1-pentanol			X			X							X			X	4
2-ethyl-1-hexanol							X	X	X	X	X	X		X	X	X	9
3,5-dimethylcyclohexanol			X												X		2
2,2,4-trimethyl-3-penten-ol			X										X		X		3
4-methylbenzene methanol					X												1
2-propyl-1-hexanol												X					1
4,5-dimethyl-2-hepten-3-ol									X								1
α-ethylbenzenemethanol				X													1
2,2-dimethyl-1-octanol								X									1
2-(1,1-dimethylethyl)cyclohexanol								X									1
4-(1,1-dimethylethyl)cyclohexanol								X									1
n-decanol					X					X			X				3
β,7-dimethyloctanol																X	1
2-propyl-1-heptanol			X				X					X	X	X	X	X	7
n-undecanol																X	1
n-dodecanol	X			X		X		X							X	X	6
2-butyloctanol				X		X	X	X				X	X	X			7
2,2-dimethyl-1-decanol						X											1
6-ethyl-4,5-decanediol												X					1
2-methyl-1-dodecanol					X												1
n-hexadecanol												X					1
n-heptadecanol												X					1
Phenols																	
phenol		X															1
2-methylphenol			X														1
2,4-dimethylphenol			X	X													2
2,3-dimethylphenol				X													1
3,4-dimethylphenol		X			X												2
2,5-dimethylphenol	X			X						X							3
3-ethylphenol										X		X					2
2-*t*-butylphenol								X									1
2-methyl-4-*t*-butylphenol			X														1

(continued)

TABLE 60 (continued)

Compounds	Elderly Home-1						Elderly Home-2			Office-1				School			Total Times Identified
	1	2	3	4	5	6	1	2	3	1	2	3	4	1	2	3	
Ketones																	
acetone	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16
methylethyl ketone	X					X											2
4-pentene-2-one			X														1
2-methyl-1-propen-1-one									X								1
dihydro-2(3H)-furanone						X											1
3-methyl-2-butanone								X									1
3-hexanone	X			X													2
4-hexene-3-one	X																1
5-hexene-2-one	X																1
3-methyl-2(5H)-furanone							X										1
2-methyl-3-pentanone									X								1
4-methyl-2-pentane												X	X				2
2-hexanone																X	1
2-heptanone							X	X	X								3
acetophenone	X	X	X	X													4
3,4-dihydro-1(2H)naphthalenone						X	X										2
indan-1-one	X					X											2
7-methyl-3-octane-2-one							X										1
5-methyl-1(3H)-isobenzofuranone										X							1
2,6-dimethyl-4-hepten-3-one												X					1
5-nonen-4-one													X				1
methylacetophenone	X			X													2
1-phenyl-1-propanone						X											1
1-ethylacetophenone							X										1
4-phenyl-3-buten-2-one							X										1
1-(2-methylphenol)ethanone										X							1
5-methyl-2-(1-methylethenyl)-cyclohexanone												X					1
2-decen-2-one			X														1
2,4-dimethylacetophenone	X		X				X			X							4
1,7,7-trimethylbicyclo-[2·2·1]heptanone	X		X				X			X							4
1-phenyl-2-pentanone						X											1
1-phenyl-1-pentanone										X							1
2,3-dihydro-4,7-dimethyl-1H-inden-1-one								X		X							2
3,3-dimethyl-1-inden-1-one										X							1
4(1-methylethyl)acetophenone										X							1
2,6-bis(1,1-dimethylethyl)-2,5-cyclohexadien-1,4-dione												X					1
benzophenone									X	X							2
5-methyl-1-phenyl-1-hexene-3-one										X							1
6,10-dimethyl-5,9-undecadine-2one												X					1

(continued)

TABLE 60 (continued)

Compounds	Elderly Home-1 1	2	3	4	5	6	Elderly Home-2 1	2	3	Office-1 1	2	3	4	School 1	2	3	Total Time Identified
Aldehydes																	
2-oxopropanal								X									1
n-butanal							X		X								2
2-methylpropanol				X													1
2-methyl-2-butenal									X								1
2-furaldehyde	X		X	X		X											4
n-hexanal								X									1
n-heptanal										X	X	X			X		4
3,3-dimethyhexanal	X		X			X											3
benzaldehyde	X	X	X	X													4
n-octanal								X									1
n-nonanal	X	X	X	X	X	X				X	X	X	X	X	X	X	13
o-methylbenzaldehyde						X	X			X							3
4-methylbenzaldehyde							X										1
3-phenyl-2-propanal										X							1
ethylbenzaldehyde							X	X		X	X						4
n-decanal	X	X	X	X	X	X					X	X	X		X		10
n-undecanal										X							1
4(1-methylethyl)benzaldehyde															X		1
n-tetradecanal								X									1
Ethers																	
methoxyethane										X							1
ethoxyethane				X													1
ethoxy-1-propene								X									1
methylbutylhydroperoxide										X							1
hexylpentylether				X													1
tetrahydrofuran	X	X	X														3
2-butyltetrahydrofuran													X				1
benzofuran			X														1
4,7-dimethylbenzofuran		X		X													2
dihydrobenzopyran								X									1
Epoxides																	
ethylene oxide	X						X		X		X						4
trimethyloxirane							X										1
ethyloxirane							X							X			1
methyloxirane									X								1
2,2-dimethyl oxirane										X							1
3,3-dimethyl oxirane							X										1
Carboxylic Acids																	
acetic acid		X					X	X	X	X	X	X		X	X	X	10
propanoic acid			X														1
propanedioic acid							X		X								2
pentanoic acid								X									1
Sulfur-containing Compounds																	
carbon disulfide	X													X			2
6-methylbenzo(b)thiophene	X																1
benzothiazole								X				X					2
thiopropanoic acid-3-sec-butyl ester													X				1
2-ethylthiophenol											X						1
Nitrogen-containing Compounds																	
propiamide	X																1
benzonitrile	X														X		2
3-methylpyrrolidine	X																1
3-methylcinnoline	X									X							2
pyridine							X										1
decylhydroxylamine												X	X			X	3

[a] See Table 59 for location identifications.

(% above the quantifiable limit) of target volatiles was calculated for each field monitoring trip. Then summary statistics including mean, median, and maximum concentrations were calculated for all targets which were measurable in 25% of the samples. For a few selected organics, correlations between concentrations at selected sites were tested using a t-test. Some comparisons of media concentrations were made between buildings and sampling trips.

A detailed description of the sampling sites and samples collected is given in Sections 4 and 5.

Computer Analysis--

Before statistical analysis could be undertaken, several manipulation were necessary to process the data collected and create computer analysis files. First, because of the difficulty of maintaining sufficient GC resolution for each pair of chemicals, the quantitative values of m-dichlorobenzene and p-dichlorobenzene, as well as m-xylene and p-xylene were added to give one total value for m,p-dichlorobenzene, and one value for m,p-xylene. Thus, all samples were more readily comparable for 18 volatile organics.

Second, values below the limit of detection (LOD) were set equal to 1/2 LOD and values at trace were set equal to 5/8 QL (quantifiable limit), where 5/8 was the midpoint between the LOD and the QL.

Third, the duplicate samples were averaged with their corresponding field samples. The median QL for a particular compound was then defined as the median of the individual quantifiable limits for each sample.

The final sample size for each field monitoring trip is given in Table 61.

Office Building--

Table 62 shows the percentage of air samples with measurable concentration of volatile organics. Data are given for samples collected both indoors and outdoors during all three trips to the office building. The table also indicates if a significant difference was found at the .05 level for percent measurable between indoor and outdoor samples when a t-test was performed.

This was the case for nine of the compounds. The ratios of percent measurables for indoor versus outdoor samples are one or greater than one

TABLE 61. NUMBER OF SAMPLES COLLECTED FOR AIR VOLATILES BY TRIP AND SITE

Site	Sample Size Available for Analysis		
	Trip 1	Trip 2	Trip 3
Office Building	24	21	24
School Building	23		
Elderly Home-1	36		
Elderly Home-2	29		

TABLE 62. PERCENT MEASURABLE - VOLATILE ORGANICS - OFFICE BUILDING OVERALL 3 TRIPS

Compound	Percent Measurable Indoor (59)[a]	 Outdoor (10)[a]	Ratio (In/Out)
Chloroform	98.3	80.0	1.3
1,2-Dichloroethane	6.8[d]	0.0	∞
1,1,1-Trichloroethane	100.0	100.0	1.0
Benzene	100.0	90.0	1.1
Carbon Tetrachloride	62.7[d]	90.0	0.7
Trichloroethylene	98.3[d]	30.0	3.3
Tetrachloroethylene	98.3[d]	80.0	1.2
Chlorobenzene	28.8[d]	0.0	∞
Styrene	98.3[d]	50.0	2.0
m,*p*-Dichlorobenzene	93.1[d]	0.0	∞
o-Dichlorobenzene	5.2	0.0	∞
Ethylbenzene	100.0	100.0	1.0
o-Xylene	100.0	100.0	1.0
m,*p*-Xylene	100.0	80.0	1.3
1,1,2,2-Tetrachloroethane	0.0	0.0	∞
n-Decane	97.8[b,d]	37.5[c]	2.6
n-Undecane	100.0[d]	62.5	1.6
n-Dodecane	100.0[d]	25.0	4.0

[a] Sample size.

[b] Sample size for *n*-decane, *n*-undecane, and *n*-dodecane indoor was 44.

[c] Sample size for *n*-decane, *n*-undecane, and *n*-dodecane outdoor was 8.

[d] Indicates a significant difference at .05 level between percent measurable for indoor versus outdoor air samples t-test.

for twelve volatiles, less than one for carbon tetrachloride and undefined for the six remaining target volatiles, none of which were detected outdoors.

Comparing the results from five indoor locations and combining indoor and outdoor locations, there were nine volatile organics with a high percent measurable. These nine compounds were chloroform, 1,1,1-trichloroethane, benzene, ethylbenzene, o-xylene, m,p-xylene, n-decane, n-undecane, and n-dodecane.

Tables 63 through 65 show percent measurables for indoor versus outdoor samples and the indoor/outdoor percent measurable ratios for the three trips to the office building. The tables have been reduced to fifteen volatile organics because the other three volatiles were detected in less than 25% of the samples collected for all sampling trips. Table 66 summarizes the indoor/outdoor percent measurable ratios by trip for all three trips. Generally, except for carbon tetrachloride, the ratio of percent measurable between indoor and outdoor samples was one or greater than one. Seven compounds had a ratio greater than one for trip 1, three compounds had ratios greater than one for trips 2 and 3. However, when data from all three trips were combined, there were nine compounds with a percent measurable ratio greater than one. The highest ratios for trip 1 were for trichloroethylene (3.8) and styrene (4.0). For the three trips combined the highest ratios were for trichloroethylene (3.3) and n-dodecane (4.0).

Table 67 shows the median quantifiable limits (QLs) for the fifteen volatile organics which had sufficient data to compute summary statistics for samples collected at all five indoor locations and for indoor and outdoor samples combined. 1,1,1-Trichloroethane and ethylbenzene were both 100% detected and thus the QLs are estimated. The lowest median QL was 0.07 $\mu g/m^3$ for n-undecane and the highest was 0.56 $\mu g/m^3$ for carbon tetrachloride.

Tables E-1 to E-18 in Appendix E give the concentration levels for volatile organics with percentage measurable greater than 20% found at the office building. Data are presented for each monitoring location for each of the three field monitoring trips to the office building. Tables 68 to 70 summarizes this information, giving mean concentration found at each location for the three trips. For the third trip to the office, high and

TABLE 63. PERCENT MEASURABLE - VOLATILE ORGANICS - OFFICE BUILDING TRIP 1, AUGUST 1983

Compound	Percent Measurable		Ratio (In/Out)
	Indoor (20)[a]	Outdoor (4)	
Chloroform	95.0	50.0	1.9
1,1,1-Trichloroethane	100.0	100.0	1.0
Benzene	100.0	75.0	1.3
Carbon Tetrachloride	20.0[b]	75.0	0.3
Trichloroethylene	95.0[b]	25.0	3.8
Tetrachloroethylene	95.0	50.0	1.9
Chlorobenzene	5.0	0.0	∞
Styrene	100.0[b]	25.0	4.0
m,*p*-Dichlorobenzene	90.0[b]	0.0	∞
Ethylbenzene	100.0	100.0	1.0
o-Xylene	100.0	100.0	1.0
m,*p*-Xylene	100.0	50.0	2.0
n-Decane	100.0[c]	100.0[d]	1.0
n-Undecane	100.0	100.0	1.0
n-Dodecane	100.0	50.0	2.0

---

[a] Sample size.

[b] Indicates a significant difference at .05 level for percent measurable between indoor versus outdoor air.

[c] Sample size for *n*-decane, *n*-undecane, and *n*-dodecane indoor was 9.

[d] Sample size for *n*-decane, *n*-undecane, and *n*-dodecane outdoor was 2.

TABLE 64. PERCENT MEASURABLE - VOLATILE ORGANICS - OFFICE BUILDING TRIP 2, SEPTEMBER 1983

Compound	Percent Measurable Indoor (19)[a]	Percent Measurable Outdoor (2)	Ratio (In/Out)
Chloroform	100.0	100.0	1.0
1,1,1-Trichloroethane	100.0	100.0	1.0
Benzene	100.0	100.0	1.0
Carbon Tetrachloride	89.5	100.0	0.9
Trichloroethylene	100.0	0.0	0.0
Tetrachloroethylene	100.0	100.0	1.0
Chlorobenzene	42.1[b]	0.0	--
Styrene	94.7	100.0	0.9
_m_,_p_-Dichlorobenzene	100.0	0.0	--
Ethylbenzene	100.0	100.0	1.0
_o_-Xylene	100.0	100.0	1.0
_m_,_p_-Xylene	100.0	100.0	1.0
_n_-Decane	94.1[c]	50.0	1.9
_n_-Undecane	100.0	50.0	1.9
_n_-Dodecane	100.0	50.0	2.0

[a] Sample size.

[b] Indicates a significant difference at .05 level for percent measurable between indoor versus outdoor air.

[c] Sample size for _n_-decane, _n_-undecane, and _n_-dodecane was 17.

TABLE 65. PERCENT MEASURABLE - VOLATILE ORGANICS - OFFICE BUILDING
TRIP 3, DECEMBER 1983

Compound	Percent Measurable		Ratio (In/Out)
	Indoor (19-20)[a]	Outdoor (4)	
Chloroform	100.0	100.0	1.0
1,1,1-Trichloroethane	100.0	100.0	1.0
Benzene	100.0	100.0	1.0
Carbon Tetrachloride	80.0[b]	100.0	0.8
Trichloroethylene	100.0	50.0	2.0
Tetrachloroethylene	100.0	100.0	1.0
Chlorobenzene	40.0[b]	0.0	∞
Styrene	100.0	50.0	2.0
m,*p*-Dichlorobenzene	94.7[b]	0.0	∞
Ethylbenzene	100.0	100.0	1.0
o-Xylene	100.0	100.0	1.0
m,*p*-Xylene	100.0	100.0	1.0
n-Decane	100.0	0.0	∞
n-Undecane	100.0	50.0	2.0
n-Dodecane	100.0	0.0	∞

[a] Sample size.

[b] Indicates a significant difference at .05 level for percent measurable indoor versus outdoor air.

TABLE 66. RATIOS OF INDOOR VS. OUTDOOR OF PERCENT MEASURABLE - VOLATILE ORGANICS - OFFICE BUILDING

Compond	Indoor/Outdoor Ratio Trip 1	 Trip 2	 Trip 3	Overall
Chloroform	1.9	1.0	1.0	1.3
1,1,1-Trichloroethane	1.0	1.0	1.0	1.0
Benzene	1.3	1.0	1.0	1.1
Carbon Tetrachloride	0.3[a]	0.9	0.8[a]	0.7[a]
Trichloroethylene	3.8[a]	0.0	2.0	3.3[a]
Tetrachloroethylene	1.9	1.0	1.0	1.2
Chlorobenzene	--	--	--	--
Styrene	4.0[a]	0.9	2.0	2.0[a]
m,p-Dichlorobenzene	--	--	--	--
Ethylbenzene	1.0	1.0	1.0	1.0
o-Xylene	1.0	1.0	1.0	1.0
m,p-Xylene	2.0	1.0	1.0	1.3[a]
n-Decane	1.0	1.9	--	2.6[a]
n-Undecane	1.0	2.0	2.0	1.6[a]
n-Dodecane	2.0	2.0	--	4.0[a]

[a] Indicates a significant difference at .05 level for percent measurable between indoor versus outdoor air.

TABLE 67. MEDIAN QLs OVER FIVE SAMPLING LOCATIONS - INDOOR/OUTDOOR AIR SAMPLES COMBINED FOR VOLATILE ORGANICS

Compound	Median QL (µg/mL)	Sample Size[a]
Chloroform	0.18	20
1,1,1-Trichloroethane	0.15[b]	0
Benzene	0.19	1
Carbon Tetrachloride	0.56	22
Trichloroethylene	0.15	19
Tetrachloroethylene	0.33	3
Chlorobenzene	0.13	27
Styrene	0.19	24
m,*p*-Dichlorobenzene	0.08	15
Ethylbenzene	0.15[b]	0
o-Xylene	0.20	2
m,*p*-Xylene	0.18	2
n-Decane	0.19	6
n-Undecane	0.07	3
n-Dodecane	0.11	7

[a] The number of samples which were below the QL.

[b] Compounds were 100% detected, QL estimated.

TABLE 68. AVERAGE CONCENTRATION OF VOLATILE ORGANICS FOUND IN THE OFFICE, TRIP 1 (JULY 1983)

Compound	Average Concentration ($\mu g/m^3$)					
	1st Floor Exterior Office	1st Floor Secretarial	2nd Floor Office	2nd Floor Secretarial	3rd Floor Copier	Outdoor
Chloroform	0.83	0.87	1.38	0.78	0.55	0.38
1,2-Dichloroethane	0.02	0.02	0.02	0.02	0.02	0.02
1,1,1-Trichloroethane	398.0	323.0	418.0	409.0	346.0	10.3
Benzene	4.9	5.4	5.1	4.6	3.2	1.5
Carbon Tetrachloride	0.23	0.75	0.85	0.17	0.19	0.86
Trichloroethylene	0.96	0.99	2.1	0.83	1.08	0.27
Tetrachloroethylene	5.64	8.4	10.7	6.2	2.6	0.64
Chlorobenzene	0.02	0.47	0.02	0.02	0.02	0.04
Styrene	0.4	7.7	7.1	10.5	6.7	0.15
m,p-Dichlorobenzene	1.2	0.89	0.9	0.79	3.3	0.06
o-Dichlorobenzene	0.12	0.09	0.2	0.09	0.09	0.06
Ethylbenzene	89.0	83.0	73.0	88.0	90.0	2.4
o-Xylene	130.0	61.0	54.0	72.0	60.0	1.4
m,p-Xylene	160.0	130.0	110.0	100.0	140.0	1.3
1,1,2,2-Tetrachloroethane	0.02	0.02	0.02	0.02	0.02	0.02
n-Decane	--[a]	430.0	320.0	400.0	380.0	3.6
n-Undecane	--[a]	150.0	180.0	200.0	166.0	1.9
n-Dodecane	--[a]	22.0	76.0	41.0	50.0	0.13

[a] Not Calculated

TABLE 69. AVERAGE CONCENTRATION OF VOLATILE ORGANICS FOUND IN THE OFFICE, TRIP 2 (SEPTEMBER, 1983)

Compound	Average Concentration (μg/m^3)					
	1st Floor Interior Office	1st Floor Secretarial	2nd Floor Office	2nd Floor Secretarial	3rd Floor Copier	Outdoor
Chloroform	1.6	2.5	1.6	1.6	1.6	0.63
1,2-Dichloroethane	0.06	0.03	0.03	0.03	0.09	0.15
1,1,1-Trichloroethane	75.0	139.0	82.0	99.0	106.0	4.2
Benzene	3.1	7.7	4.1	4.5	6.0	5.2
Carbon Tetrachloride	0.89	1.2	1.1	1.0	0.84	1.1
Trichlorethylene	36.0	46.0	38.0	39.0	31.0	0.07
Tetrachloroethylene	1.4	2.6	2.6	2.1	2.5	0.33
Chlorobenzene	0.15	0.16	0.13	0.35	0.41	0.07
Styrene	4.0	9.7	5.9	7.4	8.3	4.4
m,p-Dichlorobenzene	1.1	1.5	0.98	1.1	1.3	0.12
o-Dichlorobenzene	0.09	0.14	0.06	0.10	0.17	0.07
Ethylbenzene	4.4	6.25	4.8	7.2	8.8	1.20
o-Xylene	6.4	10.1	7.2	8.0	9.7	1.90
m,p-Xylene	16.0	20.0	16.0	19.0	23.0	3.3
1,1,2,2-Tetrachloroethane	0.03	0.03	0.03	0.03	0.03	0.02
n-Decane	39.7	50.0	39.0	25.0	37.0	0.71
n-Undecane	50.3	63.0	44.0	44.0	43.0	0.96
n-Dodecane	21.0	23.0	17.0	19.0	16.0	0.43

TABLE 70. AVERAGE CONCENTRATION OF VOLATILE ORGANICS FOUND AT THE OFFICE, TRIP 3 (DECEMBER 1983)

	Average Concentration ($\mu g/m^3$)					
Compound	1st Floor Interior Office	1st Floor Secretarial	2nd Floor Office	2nd Floor Secretarial	3rd Floor Copier	Outdoor
Chloroform	20.0	10.0	9.8	35.0	18.0	17.0
1,2-Dichloroethane	0.11	0.10	0.14	0.17	0.20	0.09
1,1,1-Trichloroethane	45.0	55.0	48.0	67.0	30.0	3.5
Benzene	6.3	3.6	2.0	8.0	13.0	3.3
Carbon Tetrachloride	1.1	0.67	0.34	1.3	0.9	0.85
Trichloethylene	32.0	33.0	30.0	24.0	16.0	0.51
Tetrachloroethylene	2.8	3.4	3.2	2.5	3.0	1.13
Chlorobenzene	0.28	0.15	0.10	0.14	0.37	0.03
Styrene	3.6	3.6	5.8	3.7	2.4	0.21
m,p-Dichlorobenzene	0.53	0.60	0.52	0.78	0.34	0.12
o-Dichlorobenzene	0.03	0.03	0.03	0.03	0.03	0.03
Ethylbenzene	4.8	4.9	4.0	4.2	5.9	1.24
o-Xylene	3.8	3.9	2.9	3.2	3.9	1.01
m,p-Xylene	9.7	11.0	7.4	8.64	8.6	2.65
1,1,2,2-Tetrachloroethane	0.03	0.03	0.03	0.03	0.03	0.03
n-Decane	4.8	7.1	4.7	2.4	2.4	0.06
n-Undecane	25.0	20.0	8.5	5.6	5.8	0.33
n-Dodecane	7.8	6.4	3.4	2.1	2.8	0.12

variable levels of chloroform were found on field blanks and although data has been presented, results are questionable for this compound. Tables 71 through 74 give the summary statistics for these data. Mean, median, and maxium concentrations have been determined. The summary statistics are given for indoor and outdoor samples separately. Median and maximum indoor/outdoor concentration ratios have also been calculated.

To do a test on analysis of variance on these data, first the natural log of the individual concentrations was taken. The model used was concentration values = period, location. Period refers to day or night indoor concentrations and location refers to concentrations for indoor locations only. Significant differences in reported concentration between time periods or indoor location are indicated in Tables 71 through 74. Trips 1 and 3 show concentration differences for several compounds for day versus night samples with daytime samples showing highest concentrations. For trip 3, there are significant differences in reported concentrations among the locations for seven of the target volatiles. Table 70 shows average concentrations at each location.

In order to perform a valid paired t-test for indoor versus outdoor concentrations, the indoor air sample concentrations had to be averaged over each of the time periods. For the second visit to the office building only two outdoor air samples were collected; therefore, the paired t-test was performed overall but not by trip. Trip 1 and 3 each had four outdoor air samples. Trips 1 and 3 each had four time periods both indoors and outdoors. In order for each trip (1 and 3) to have four matched pairs, each of the five indoor samples was averaged by the time period per sample. Trip 2 had only two outdoor samples. Thus, the sample file consists of ten matched pairs -- four each for trips 1 and 3, and two for trip 2. Then the difference (outdoor concentration minus the indoor mean concentration) was taken and the t-test was performed over all three trips on the fifteen compounds. Thirteen of the fifteen compounds showed a significant difference at the 0.05 level as reported in Table 71. Only chloroform and carbon tetrachloride did not.

Table 71 contains the statistics for volatile organic compounds for the three combined trips for the office building. The indoor mean, median, and maximum concentrations and indoor/outdoor ratios for the median and maximum concentrations are largest for 1,1,1-trichloroethane, trichloroethylene,

TABLE 71. SUMMARY STATISTICS - VOLATILE ORGANICS - 3 TRIPS COMBINED - OFFICE BUILDING[a]

Compound	Median QL	Concentration ($\mu g/m^3$) Mean Indoor	Mean Outdoor	Median Indoor	Median Outdoor	Max Indoor	Max Outdoor	Ratio Median (In/Out)	Ratio Max (In/Out)
Chloroform	0.10	7.1	7.2	1.5	0.74	110.	48.	2.0	2.3
1,1,1-Trichloroethane	0.15[b]	180.[d,e]	6.3	93.	4.6	870.	15.	20.	58.
Benzene	0.19	6.1[d,e]	3.0	4.4	2.9	48.	6.2	1.5	7.7
Carbon Tetrachloride	0.56	0.76	0.90	0.68	0.89	3.1	1.4	0.8	2.2
Trichloroethylene	0.38	21.[d,e]	0.33	19.	0.21	80.	1.1	91.	73.
Tetrachloroethylene	0.33	4.0[e]	0.78	2.2	0.44	17.	2.4	5.0	7.1
Chlorobenzene	0.17	0.19[e]	0.04	----[c]	----[c]	1.8	0.13	---[c]	14.
Styrene	0.16	6.4[e]	1.0	5.4	0.19	18.	8.2	28.	2.2
m,p-Dichlorobenzene	0.11	1.1[e]	0.10	0.98	0.11	9.6	0.18	8.9	53.
Ethylbenzene	0.15[b]	32.[d,e]	1.7	6.8	1.2	200.	4.1	5.7	49.
o-Xylene	0.15[b]	29.[e]	1.4	8.3	1.4	340.	2.4	6.1	140.
m,p-Xylene	0.18	56.[e]	2.2	19.	2.4	340.	3.9	7.9	87.
n-Decane	0.19	92.[e]	1.1	35.	0.1	780.	5.6	350.	140.
n-Undecane	0.07	59.[e]	0.87	38.	0.55	320.	2.2	68.	150.
n-Dodecane	0.14	19.[e]	0.20	16.	0.14	110.	0.84	110.	130.

[a] Indoor sample size was 59, except sample size for n-decane, n-undecane, and n-dodecane was 45. Outdoor sample size was 10, except sample size for n-decane, n-undecane, and n-dodecane was 8.

[b] Compounds were 100% detected, estimated QL.

[c] Both percents detectable were less than 50%, therefore medians were not compared.

[d] Indicates a significant difference in concentrations at 0.05 level when performing analysis of variance to test for a difference in day versus night, with daytime levels higher than nighttime.

[e] Indicates a significant difference between indoor and outdoor concentrations at 0.05 level when performing paired t-test.

TABLE 72. SUMMARY STATISTICS - VOLATILE ORGANICS - TRIP 1, JULY 1983 - OFFICE BUILDING[a]

Compound	Median QL	Concentration ($\mu g/m^3$) Mean Indoor	Mean Outdoor	Median Indoor	Median Outdoor	Max Indoor	Max Outdoor	Ratio Median (In/Out)	Ratio Max (In/Out)
Chloroform	0.10	0.88[b]	0.38	0.81	0.32	3.3	0.71	2.5	4.6
1,1,1-Trichloroethane	0.15	380.[b]	10.	290.	11.	870.	15.	26.	58.
Benzene	0.19	4.6[b]	1.5	4.7	1.6	8.5	2.9	3.0	2.9
Carbon Tetrachloride	0.6	0.44[b]	0.86	0.08	0.88	2.9	1.2	0.1	2.4
Trichloroethylene	0.26	1.2	0.27	1.1	0.21	3.6	0.60	5.2	6.0
Tetrachloroethylene	0.33	6.7	0.64	4.6	0.36	17.	1.8	13.	9.4
Chlorobenzene	0.17	0.11	0.04	---[d]	----[d]	1.8	0.10	1.0[d]	18.
Styrene	0.16	8.3	0.15	8.6	0.06	18.	0.47	140.	38.
m,p-Dichlorobenzene	0.17	1.4	0.06	1.1	0.06	9.6	0.11	18.	87.
Ethylbenzene	0.15[c]	84.[b]	2.4	82.	2.3	200.	4.1	35.	49.
o-Xylene	0.15[c]	74.[b]	1.4	54.	1.4	340.	2.2	39.	150.
m,p-Xylene	0.18	140.	1.3	150.	0.96	340.	3.1	160.	110.
n-Decane	0.15[c]	380.	3.6	310.	3.55	780.	5.6	87.	140.
n-Undecane	0.15[c]	170.	1.9	150.	1.9	320.	2.2	81.	150.
n-Dodecane	0.18	47.	0.13	44.	0.13	110.	0.24	340.	460.

[a] Indoor sample size was 20, except the sample size for n-decane, n-undecane, and n-dodecane was 9. Outdoor sample size was 4, except sample size for n-decane, n-undecane, and n-dodecane was 2.

[b] Indicates a significant difference in concentration at 0.05 level when performing analysis of variance to test for a difference in day versus night, with daytime levels being higher.

[c] Compounds were 100% detected, estimated QL.

[d] Both percents detectable were less than 50%, therefore medians were not compared.

TABLE 73. SUMMARY STATISTICS - VOLATILE ORGANICS - TRIP 2, SEPTEMBER 1983 - OFFICE BUILDING[a]

Compound	Median QL	Concentration ($\mu g/m^3$)						Ratio	
		Mean		Median		Max		Median	Max
		Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	(In/Out)	(In/Out)
Chloroform	0.15[b]	1.8[c,d]	0.63	1.5	0.63	4.4	0.76	2.4	5.8
1,1,1-Trichloroethane	0.15[b]	100.	4.2	88.	4.2	270.	4.4	21.	61.
Benzene	0.15[b]	7.1	5.2	4.6	5.2	48.	6.2	0.9	7.7
Carbon Tetrachloride	0.21	1.0	1.1	0.92	1.1	1.7	1.3	0.8	1.3
Trichloroethylene	0.58	38.[c]	0.07	27.	0.07	80.	0.08	390.	1000.
Tetrachloroethylene	0.15[b]	2.3[c]	0.33	2.1	0.33	5.2	0.42	6.4	12.
Chlorobenzene	0.19	0.25	0.07	----[e]	----[e]	0.78	0.13	----[e]	6.0
Styrene	0.15[b]	7.2	4.4	6.3	4.4	16.	8.2	1.4	2.0
m,p-Dichlorobenzene	0.08	1.2[d]	0.12	1.2	0.12	1.7	0.13	10.	13.
Ethylbenzene	0.15[b]	6.4	1.2	6.8	1.2	10.	1.2	5.7	8.3
o-Xylene	0.15[b]	8.4	1.9	8.4	1.9	13.	2.4	4.4	5.4
m,p-Xylene	0.15[b]	19.	3.3	19.	3.3	27.	3.6	5.8	7.5
n-Decane	0.19	38.	0.71	40.	0.71	61.	1.4	56.	44.
n-Undecane	0.19	48.	0.96	49.	0.96	88.	1.9	51.	46.
n-Dodecane	0.19	19.	0.43	19.	0.43	30.	0.84	43.	36.

[a] Indoor sample size was 19 except the sample for n-decane, n-undecane, and n-dodecane was 17. Outdoor sample size was 2.

[b] Compounds were 100% detected, estimated QL.

[c] Indicates a significant difference in concentrations at 0.05 level when performing analysis of variance to test for a difference in day versus night, with daytime levels being higher.

[d] Indicates a significant difference in concentration at 0.05 level when performing analysis of variance to test for differences among the 5 indoor locations.

[e] Both percents detectable were less than 50%, therefore medians were not compared.

TABLE 74. SUMMARY STATISTICS - VOLATILE ORGANICS - TRIP 3, DECEMBER 1983 - OFFICE BUILDING[a]

		Concentration ($\mu g/m^3$)						Ratio	
		Mean		Median		Max		Median	Max
Compound	Median QL	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	(In/Out)	(In/Out)
Chloroform	0.15[b]	18.	17.	13.	9.9	110.	48.	1.3	2.3
1,1,1-Trichloroethane	0.15[b]	49.[c]	3.5	41.	3.3	170.	6.4	12.	27.
Benzene	0.15[b]	6.6[c,d]	3.3	3.6	3.4	25.	6.0	1.1	4.2
Carbon Tetrachloride	0.17	0.86[d]	0.85	0.76	0.78	3.1	1.4	1.0	2.2
Trichloroethylene	0.26	27.	0.51	25.	0.44	51.	1.1	56.	46.
Tetrachloroethylene	0.15[b]	3.0[c]	1.1	1.7	0.88	8.6	2.4	1.9	3.6
Chlorobenzene	0.09	0.21[c,d]	0.03	----[e]	----[e]	0.67	2.4	----[e]	17.
Styrene	0.15	3.8[c,d]	0.21	3.4	0.19	7.5	0.44	18.	17.
m,p-Dichlorobenzene	0.11	0.56[c]	0.12	0.50	0.14	1.4	0.18	3.6	6.1
Ethylbenzene	0.15[b]	4.8[c]	1.2	4.5	1.3	11.	1.9	3.6	5.8
o-Xylene	0.15[b]	3.5[c]	1.0	3.2	0.99	7.2	1.5	3.2	4.8
m,p-Xylene	0.15[b]	9.0[c]	2.7	8.2	2.7	18.	3.9	3.0	4.6
n-Decane	0.19	4.4[c,d]	0.06	4.1	0.03	11.	0.18	140.	61.
n-Undecane	0.07	13.[c,d]	0.33	9.7	0.30	37.	0.61	32.	61.
n-Dodecane	0.11	4.6[c,d]	0.12	3.9	0.14	10.	0.18	28.	56.

[a] Indoor sample size was 20 except the sample for m,p-dichlorobenzene, n-decane, n-undecane, and n-dodecane was 19. Outdoor sample size was 4.

[b] Compounds were 100% detected, estimated QL.

[c] Indicates a significant difference in concentrations at 0.05 level when performing analysis of variance to test for a difference in day versus night, with daytime levels being higher.

[d] Indicates a significant difference in concentration at 0.05 level when performing analysis of variance to test for differences among the 5 indoor locations.

[e] Both percents detectable were less than 50%, therefore medians were not compared.

m,p-xylene, n-decane, n-undecane, and n-dodecane. The median concentration ratios are greater than one in all cases, except for carbon tetrachloride, and are greater than one in all cases for the maximum ratios. The median concentration ratios are as large as 350 for n-decane, indicating that the indoor air concentrations are higher than the outdoor air concentrations.

Table 72 shows the summary statistics for trip 1 to the office building for indoor versus outdoor sample concentration. In all cases, except for carbon tetrachloride, the mean, median, and maximum concentrations are larger for indoor compared to the outdoor samples. The highest median concentration ratios are for styrene (140), m,p-xylene (160), and n-dodecane (340).

Table 73 shows the summary statistics for trip 2 to the office building for indoor versus outdoor sample concentrations. In all cases, except for benzene and carbon tetrachloride, the median concentrations are larger for indoor than for outdoor air samples. Median carbon tetrachloride concentrations are slightly less for indoor than outdoor samples. The maximum indoor concentrations in all cases are larger than the outdoor concentrations. The four largest indoor/outdoor median concentration ratios are for trichloroethylene (390), n-decane (56), n-undecane (51), and n-dodecane (43).

Table 74 contains the summary statistics for the third trip to the office building for indoor versus outdoor sample concentrations. In this case, all mean, median, and maximum concentrations are equal or larger for indoor samples. The four largest indoor/outdoor median concentration ratios are for trichloroethylene (56), n-decane (140), n-undecane (32), and n-dodecane (28).

Table 75 is a summary table of the ratios of indoor versus outdoor median air concentrations for the office building by trip, overall, and for trip 1, time period 1 only. In most cases, the ratios are larger than one indicating larger concentrations indoors than outdoors. The four largest overall indoor/outdoor median ratios are for trichloroethylene (91), n-decane (350), n-undecane (68), and n-dodecane (110). In general, these ratios decrease with time.

Table 76 is a summary table indicating the indoor/outdoor median concentrations for the office building by trip and overall. Generally, the

TABLE 75. SUMMARY STATISTICS - VOLATILE ORGANICS - OFFICE BUILDING - RATIOS OF CONCENTRATIONS

Compound	Trip 1[a] Median (In/Out)	Trip 1[a] Max (In/Out)	Trip 2[b] Median (In/Out)	Trip 2[b] Max (In/Out)	Trip 3[c] Median (In/Out)	Trip 3[c] Max (In/Out)	Overall Trips Median (In/Out)	Overall Trips Max (In/Out)
Chloroform	2.5	4.6	2.4	5.8	1.3	2.3	2.0	2.3
1,1,1-Trichloroethane	26.	58.	21.	61.	12.	27.	20.	58.
Benzene	3.0	2.9	0.9	7.7	1.1	4.2	1.5	7.7
Carbon Tetrachloride	0.1	24.	0.8	1.3	1.0	2.2	0.8	2.2
Trichloroethylene	5.2	6.0	390.	1000.	56.	46.	91.	73.
Tetrachloroethylene	13.	9.4	6.4	12.	1.9	3.6	5.0	7.1
Chlorobenzene	---[d]	18.	---[d]	6.0	---[d]	17.	---[d]	14.
Styrene	140.	38.	1.4	2.0	18.	17.	28.	2.2
m,p-Dichlorobenzene	18.	87.	10.	13.	3.6	6.1	8.9	53.
Ethylbenzene	35.	48.	5.7	8.3	3.6	5.8	5.7	42.
o-Xylene	39.	150.	4.4	5.4	3.2	4.8	6.1	140.
m,p-Xylene	160.	110.	5.8	7.5	3.0	4.6	7.9	87.
n-Decane	87.	140.	56.	44.	140.	61.	NC[e]	140.
n-Undecane	81.	150.	51.	46.	32.	61.	68.	150.
n-Dodecane	340.	460.	43.	36.	28.	56.	110.	130.

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[a] August 1983.

[b] September 1983 .

[c] December 1983.

[d] Both percent detectabls were less than 50%, therfore medians were not compared.

[e] Not calculated.

TABLE 76. SUMMARY STATISTICS - VOLATILE ORGANICS - OFFICE BUILDING - MEDIAN CONCENTRATIONS

Compound	Median Concentrations (μg/m^3)							
	Trip 1[a]		Trip 2[b]		Trip 3[c]		Overall	
	In	Out	In	Out	In	Out	In	Out
Chloroform	0.81	0.32	1.5	0.63	13.	9.9	1.5	0.74
1,1,1-Trichloroethane	290.	11.	88.	4.2	41.	3.3	93.	4.6
Benzene	4.7	1.6	4.6	5.2	3.6	3.4	4.4	2.9
Carbon Tetrachloride	0.08	0.88	0.92	1.1	0.76	0.78	0.68	0.89
Trichloroethylene	1.1	0.21	27.	0.07	25.	0.44	19.	0.21
Tetrachloroethylene	4.6	0.36	2.1	0.33	1.7	0.88	2.2	0.44
Chlorobenzene	----[d]	----[d]	----[d]	----[d]	----[d]	----[d]	----[d]	----[d]
Styrene	8.6	0.06	6.3	4.4	3.4	0.19	5.4	0.19
m,p-Dichlorobenzene	1.1	0.06	1.2	0.12	0.50	0.14	0.98	0.11
Ethylbenzene	82.	2.3	6.8	1.2	4.5	1.3	6.8	1.2
o-Xylene	54.	1.4	8.4	1.9	3.2	0.99	8.3	1.4
m,p-Xylene	150.	0.96	19.	3.3	8.2	2.7	19.	2.4
n-Decane	310.	3.6	40.	0.71	4.1	0.03	35.	0.10
n-Undecane	150.	1.9	49.	0.96	9.7	0.30	38.	0.55
n-Dodecane	44.	0.13	19.	0.43	3.9	0.14	16.	0.14

[a] August 1983.

[b] September 1983.

[c] December 1983.

[d] Both percents detectable were less than 50%, therefore medians were not compared.

indoor concentrations are higher than the outdoor concentrations. Overall, the three largest indoor/outdoor median concentration ratios are for 1,1,1-trichloroethane (93), n-decane (35), and n-undecane (38).

Visual inspection of the concentration data for trip one to the office building (Appendix E, Tables E-1 to E-6) shows large increases in indoor concentrations of some of the target volatiles during time period 2 with a gradual decrease in concentration during periods 3 and 4.

The high concentrations of the aromatic and aliphatic hydrocarbons during periods 2 (day 1), 3, and 4 were most likely due to activities which occurred within the building during that period. This trip to the office took place immediately after completion of the building. During the sampling period some "finishing" of the building and moving activities were taking place. During time period 2 (day 1), all of the furniture was being moved into the building and cleaned with a hydrocarbon-based solvent. Use of this solvent would cause a large increase in the measured hydrocarbon level; concentrations for periods 3 and 4 would decrease due to air exchange in the building. To investigate these occurences, summary statistics were calculated for the first time period (night 1) versus time periods 2 (day 1), 3 (night 2), and 4 (day 2) combined. Median and maximum concentration ratios were then calculated using time period 1 as the baseline which represents a new building without the moving activities (time periods 2, 3, and 4/day 1). Results in Table 77 show highest median ratios for ethyl benzene, o-xylene, m,p-xylene, and benzene. n-Decane and n-undecane also showed ratios greater than one for both median and maximum concentration.

Table 78 shows the ratios calculated for median and maximum indoor sample concentrations for two cases. The first case shows trip 1 versus trip 3 data. The second case shows trip 1, time period 1 versus trip 3.

Table 79 lists the outdoor concentrations for the office building for trip 1 and trip 3 and their ratios for median and maximum concentrations. Six median trip 1/trip 3 concentration ratios are greater than one; the remaining nine are less than one and range from 0.03 (chloroform) to 0.9 (n-dodecane). This table demonstrates that although there was a decrease in indoor concentrations for target volatiles between trip 1 and trip 3, this same relationship is not true for the outdoor concentrations for trips 1 and 3.

TABLE 77. SUMMARY STATISTICS - VOLATILE ORGANICS - TRIP 1 - OFFICE BUILDING[a] - INDOOR CONCENTRATIONS TIME 1 (T1) VS. TIME 2,3, AND 4 (T2,3,4)

Compound	Median QL	Concentration (μg/m³)						Ratio	
		Mean		Median		Max		Median	Max
	T1,2,3,4	T1	T2,3,4	T1	T2,3,4	T1	T2,3,4	T2,3,4/T1	T2,3,4/T1
Chloroform	0.18	0.96	0.85	0.99	0.76	1.2	3.3	.8	2.8
1,1,1-Trichloroethane	0.15[b]	311.	400.	260.	410.	510.	870.	1.6	1.7
Benzene	0.15[b]	2.8	5.2	1.4	4.7	5.7	8.5	3.4	1.5
Carbon Tetrachloride	0.56	1.2	0.18	0.46	0.08	2.9	0.66	0.2	0.2
Trichloroethylene	0.15	1.5	1.1	1.2	1.1	3.0	3.6	0.9	1.2
Tetrachloroethylene	0.40	4.8	7.3	4.8	4.5	8.1	17.	0.9	2.1
Chlorobenzene	0.11	0.02	0.14	----[c]	----[c]	0.02	1.8	---[c]	90.
Styrene	0.20	7.8	8.5	7.9	9.0	14.	18.	1.1	1.3
m,p-Dichlorobenzene	0.07	1.2	1.5	1.2	1.0	1.8	9.6	0.8	5.3
Ethylbenzene	0.15[b]	10.	110.	7.5	110.	18.	200.	15.	11.
o-Xylene	0.20	14.	95.	13.	64.	19.	340.	5.	18.
m,p-Xylene	0.15[b]	38.	170.	39.	160.	46.	340.	4.	7.4
n-Decane	0.19	210.	470.	200.	450.	310.	780.	2.3	2.5
n-Undecane	0.15[b]	130.	190.	96.	200.	210.	320.	2.	1.5
n-Dodecane	0.07	66.	38.	50.	43.	56.	110.	0.9	2.0

[a] Sample size for time 1 was 5 except sample size for n-decane, n-undecane, and n-dodecane was 3. Sample size for time 2,3, and 4 was 13 except sample size for n-decane, n-undecane, and n-dodecane was 6.

[b] Compounds were 100% detected, estimated QL.

[c] Both percent detectables were less than 50%, therefore medians were not compared.

TABLE 78. CONCENTRATION RATIOS FOR OFFICE BUILDING - INDOOR ONLY

	Concentration Ratios			
	Trip 1/Trip 3		Trip 1-1[a]/Trip 3	
Compound	Median	Max	Median	Max
Chloroform	0.06	0.1	0.07	0.01
1,1,1-Trichloroethane	7.1	5.1	6.3	3.9
Benzene	1.3	0.3	0.4	0.2
Carbon Tetrachloride	0.1	0.9	0.6	0.9
Trichloroethylene	0.02	0.1	0.5	0.06
Tetrachloroethylene	2.8	2.0	2.8	0.9
Chlorobenzene	0.1	2.7	NC	0.93
Styrene	2.6	2.4	2.3	1.9
m,p-Dichlorobenzene	2.1	6.9	2.4	1.3
Ethylbenzene	18.	18.	1.7	1.6
o-Xylene	17.	47.	4.1	2.6
m,p-Xylene	18.	19.	4.7	2.6
n-Decane	76.	71.	49.	28.
n-Undecane	16.	9.	99.	5.7
n-Dodecane	11.	11.	13.	5.6

[a] Trip 1 - time period 1 only.

Figures 23 through 25 are plots of the indoor median versus the outdoor median concentrations for the office building by trip. Again, these figures show the indoor, trip 1, median concentrations to be larger than outdoor, trip 1, median concentrations. Also, there is usually a decrease in indoor concentrations for trip 2 and trip 3 compared to trip 1. 1,1,1-Trichloroethane, ethylbenzene, o-xylene, m,p-xylene, n-decane, n-undecane, and n-dodecane show this trend. The outdoor concentrations tend to be more or less constant.

Figures 26 through 28 show the median indoor concentrations for three trips combined for the copier room only for day versus night for the fifteen selected compounds. In nine of the fifteen cases the daytime median concentration is higher than the nighttime median concentration. This is true for chloroform, trichloroethylene, tetrachloroethylene, ethylbenzene, o-xylene, 1,1,1-trichloroethane, styrene, m,p-dichlorobenzene, and m,p-xylene.

Figures 29 through 31 show the median concentrations for three trips combined for the copier room versus all other rooms for daytime only. In five cases, median concentrations for samples collected in the copier room are higher than for samples collected in the other rooms. These are m,p-dichlorobenzene, ethylbenzene, o-xylene, m,p-xylene, and styrene.

School, Elderly Homes 1 and 2--

Table 80 shows the percentages of air samples with measurable concentrations of target volatiles in indoor and outdoor samples collected during field sampling at the school. Except for chloroform and chlorobenzene, both indoor and outdoor locations have percent measurables greater than 50%. Ratios of percent measurable in indoor versus outdoor samples were also calculated. Excluding the lowest ratio (0.4 for chloroform) and the highest (1.5 for styrene), the remaining range is from 0.9 to 1.2, with a value of 1.0 for nine of the indoor/outdoor percent measurable ratios demonstrating few differences between indoor and outdoor samples.

Tables 81 and 82 give the same information for the elderly homes 1 and 2. For elderly home-1, all compounds for indoor and outdoor samples are greater than 50% measurable except for 1,2-dichloroethane, o-dichlorobenzene, and 1,1,2,2-tetrachloroethane. Excluding these three

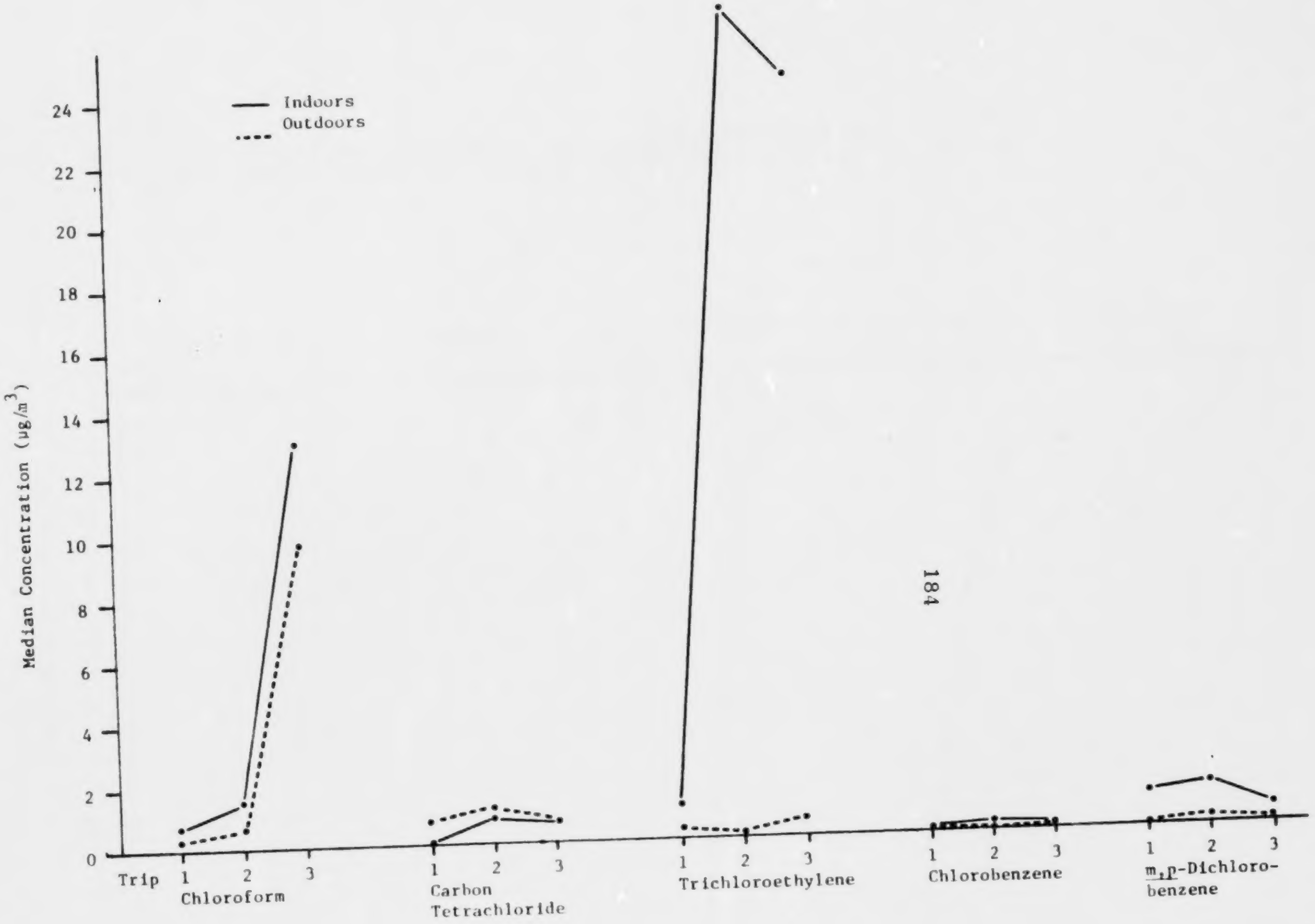

Figure 23. Indoor median vs. outdoor median concentrations of target volatiles found in the office building by trip.

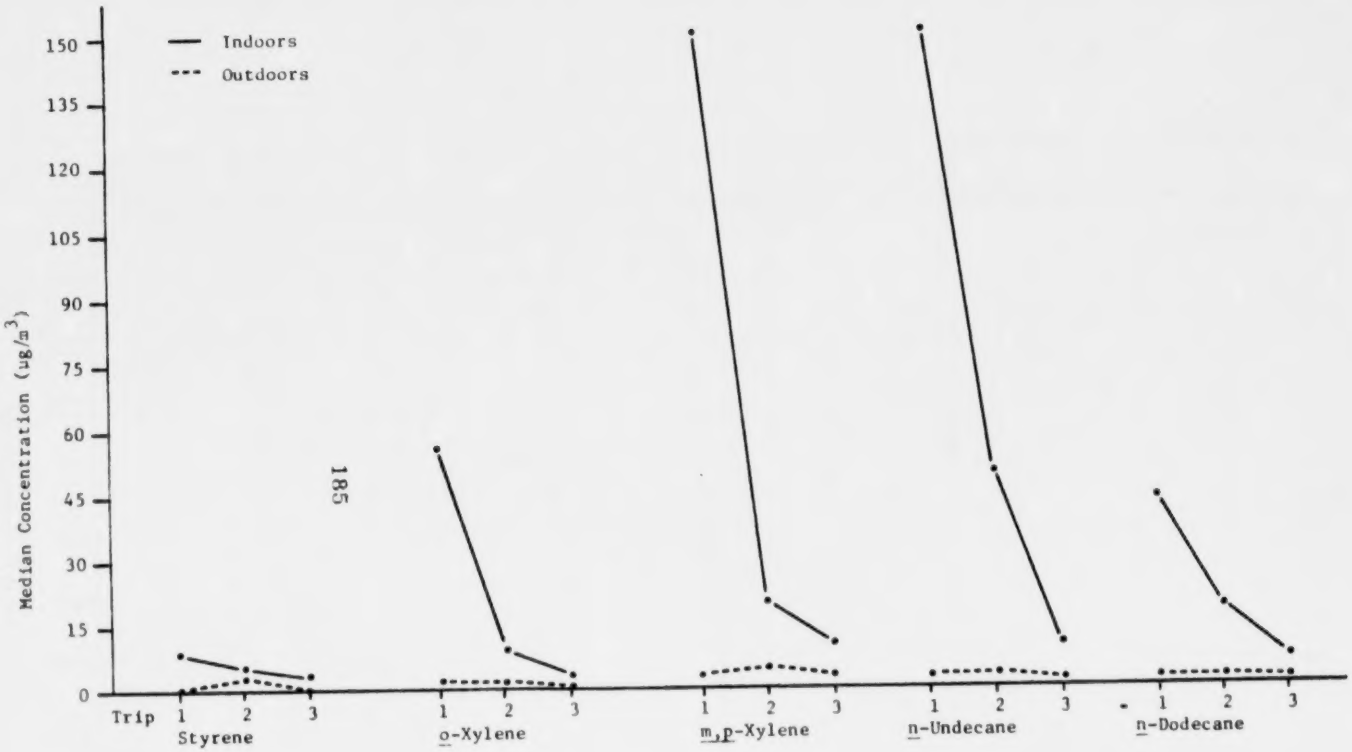

Figure 24. Indoor median vs. outdoor median concentrations of target volatiles found in the office building by trip.

TABLE 79. OFFICE BUILDING - OUTDOOR CONCENTRATIONS AND CONCENTRATION RATIOS (TRIPS 1 AND 3)

	Concentration (μg/m^3)					
	Trip 1		Trip 3		Ratio[a]	
Compound	Median	Max	Median	Max	Median	Max
Chloroform	0.32	0.71	9.9	48.	0.03	0.01
1,1,1-Trichloroethane	11.	15.	3.3	6.4	3.3	2.3
Benzene	1.6	2.9	3.4	6.0	0.5	0.5
Carbon Tetrachloride	0.88	1.2	0.78	1.4	1.1	0.9
Trichloroethylene	0.21	0.60	0.44	1.1	0.5	0.5
Tetrachloroethylene	0.36	1.80	0.88	2.4	0.4	0.8
Chlorobenzene	0.02	0.10	0.03	0.04	0.7	2.5
Styrene	0.06	0.47	0.19	0.44	0.3	1.1
m,p-Dichlorobenzene	0.06	0.11	0.14	0.18	0.4	0.6
Ethylbenzene	2.3	4.1	1.3	1.9	1.9	2.2
o-Xylene	1.4	2.2	0.99	1.5	1.4	1.5
m,p-Xylene	0.96	3.1	2.7	3.9	0.4	0.8
n-Decane	3.6	5.6	0.03	0.18	120.	31.
n-Undecane	1.9	2.2	0.30	0.61	6.2	3.6
n-Dodecane	0.13	0.24	0.14	0.18	0.9	1.3

[a] Concentration ratio trip 1/trip 3.

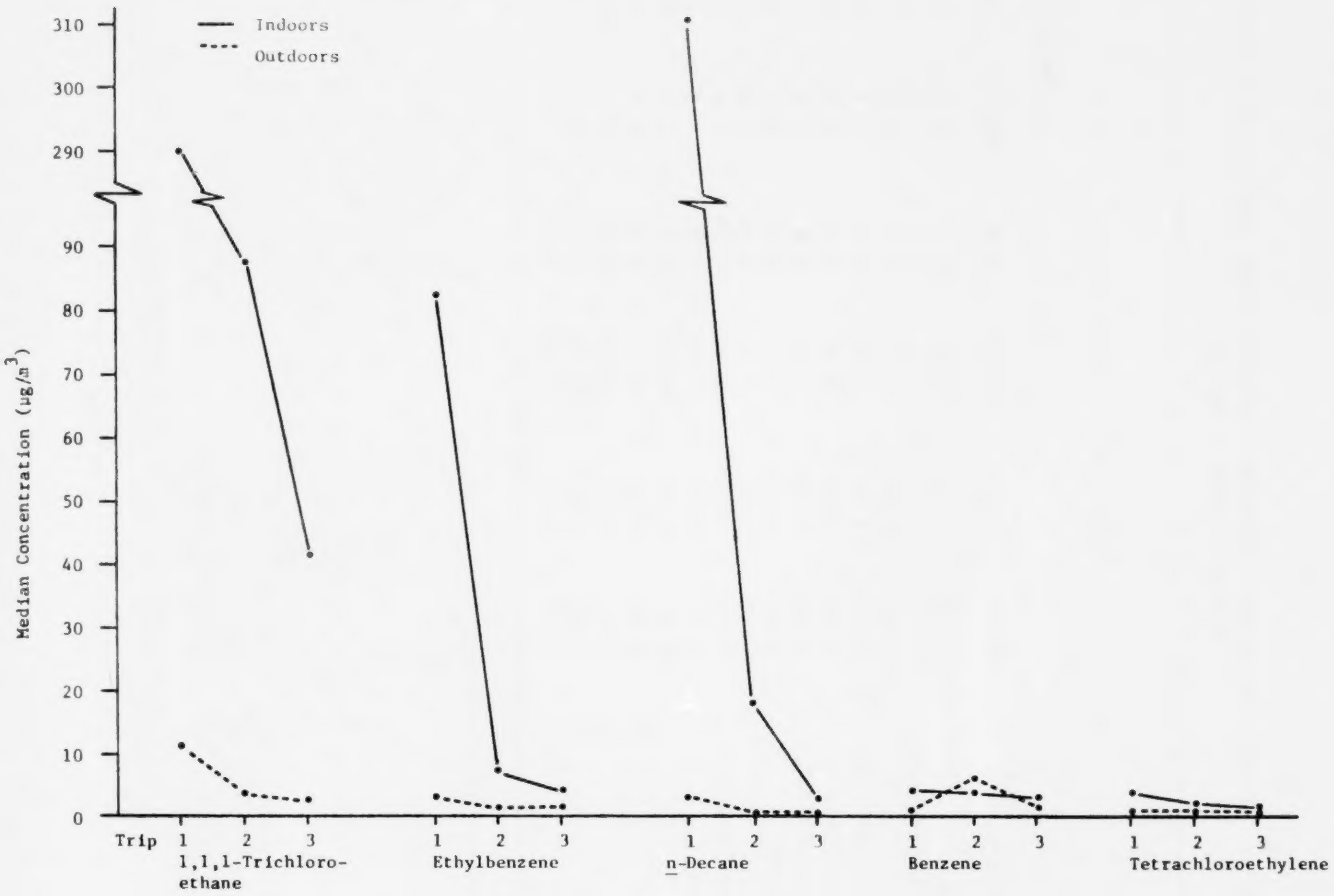

Figure 25. Indoor medians vs. outdoor median concentrations of target volatiles found in the office building by trip.

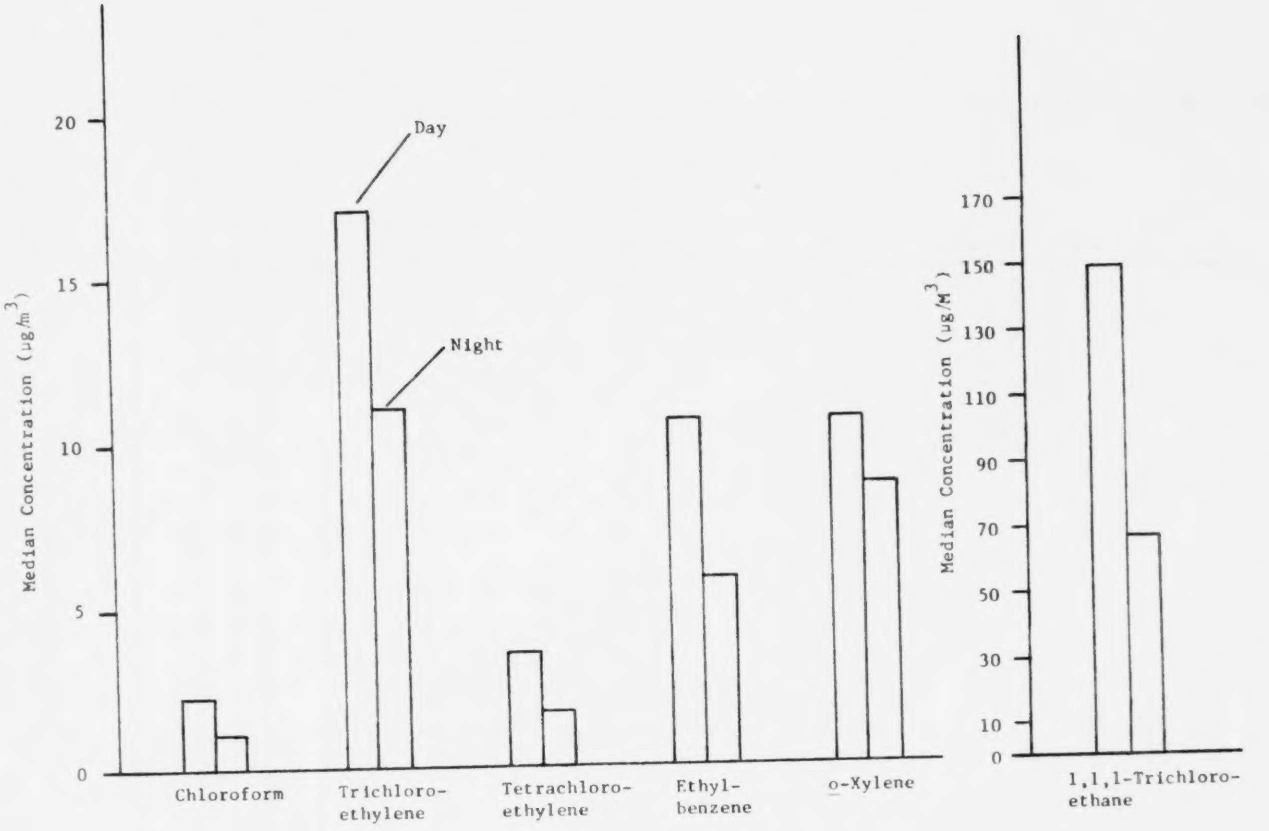

Figure 26. Median concentrations for all 3 trips to the office building - copier room only - day vs. night.

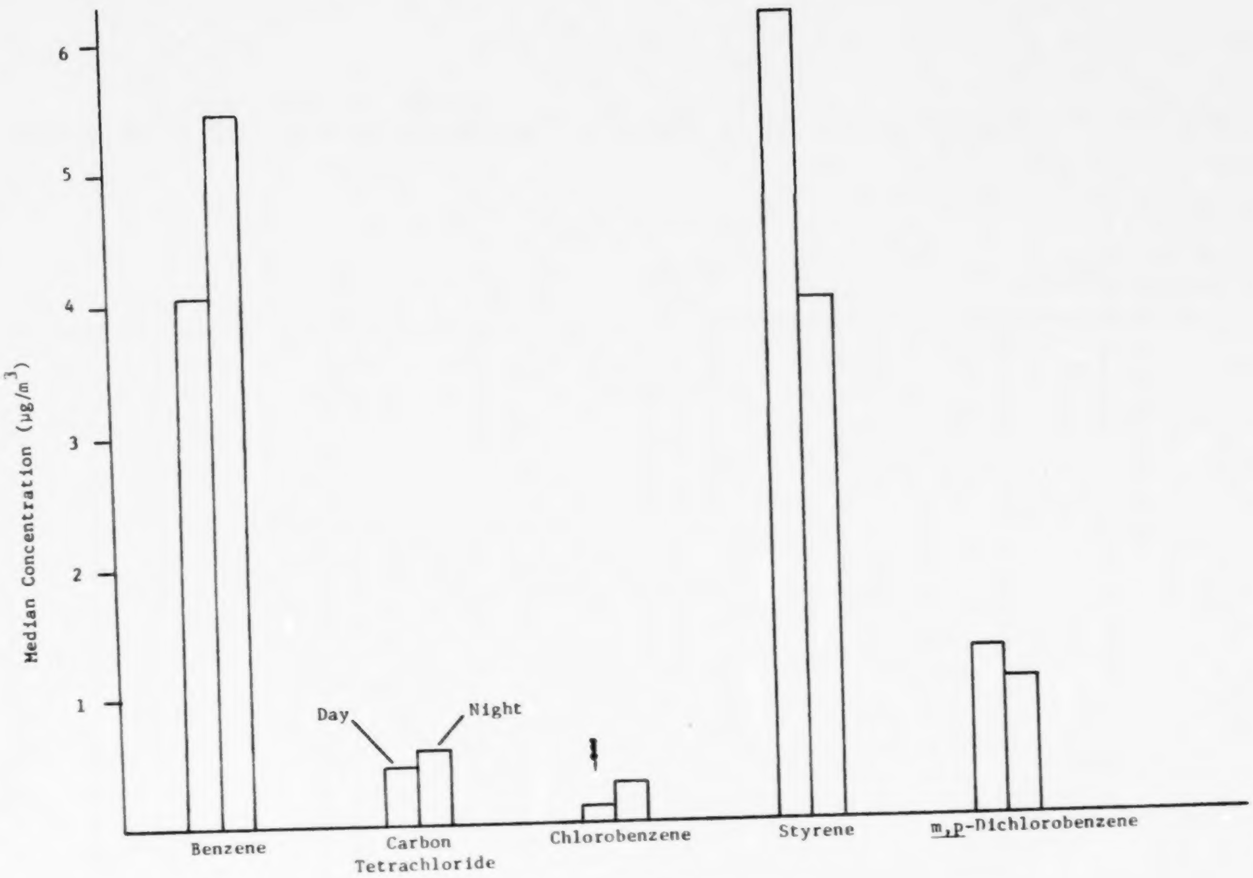

Figure 27. Median concentrations for all 3 trips to the office building - copier room only - day vs. night.

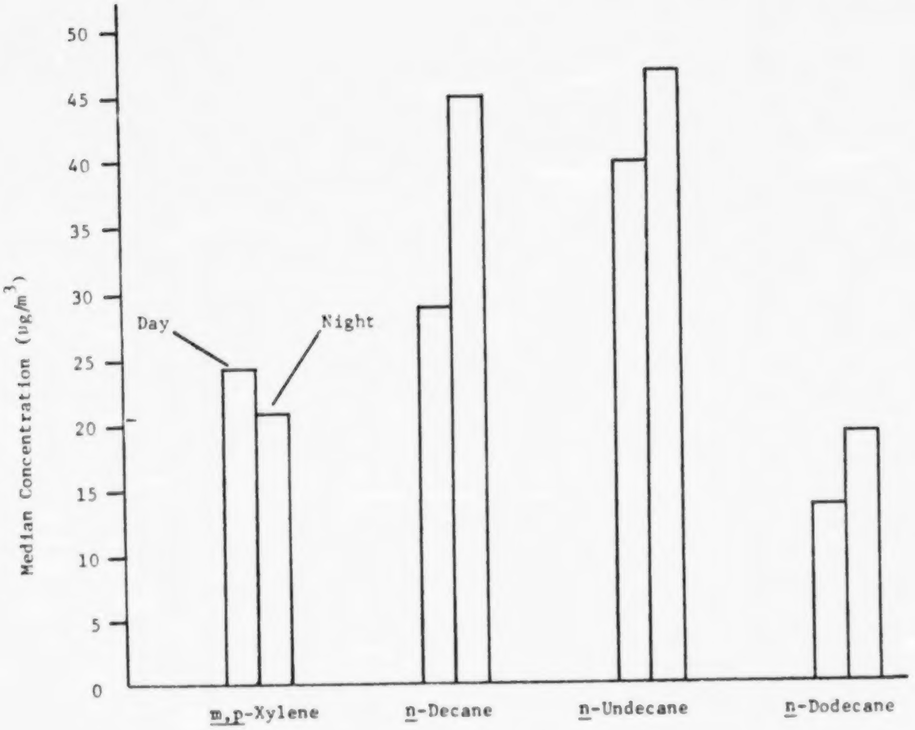

Figure 28. Median concentrations for all 3 trips to the office building - copier room only - day vs. night.

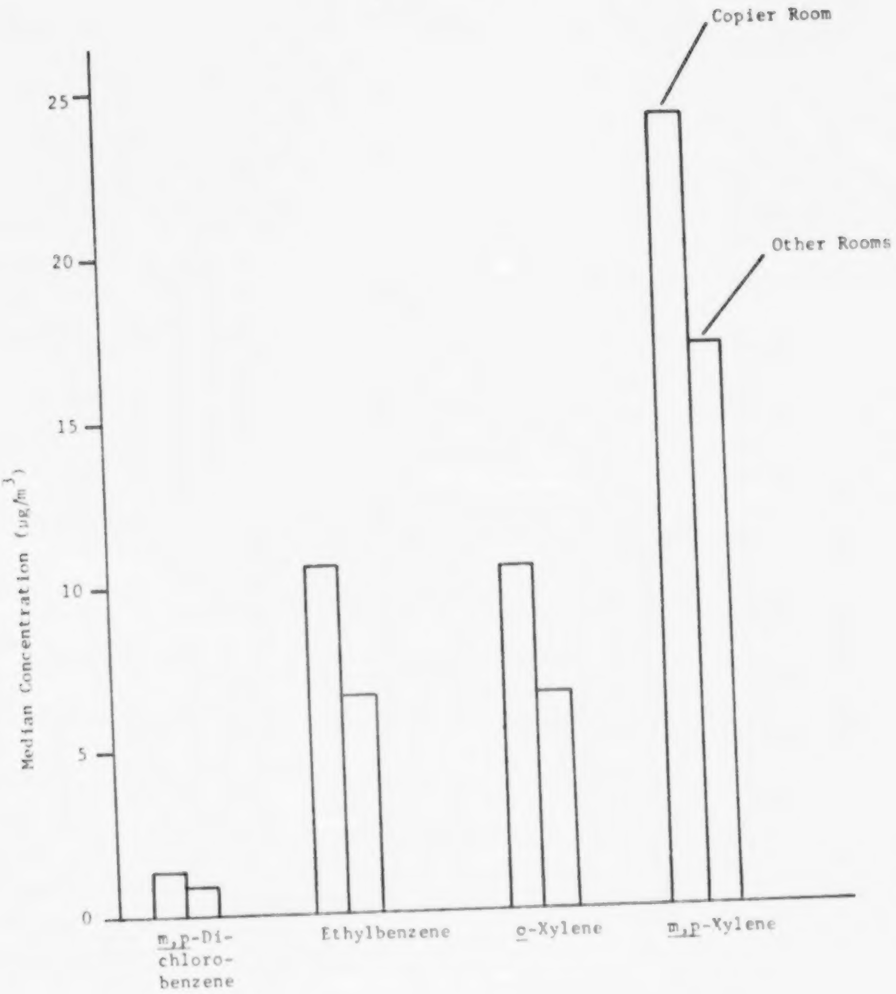

Figure 29. Median concentrations for all 3 trips to the office building - copier room vs. other rooms - daytime only.

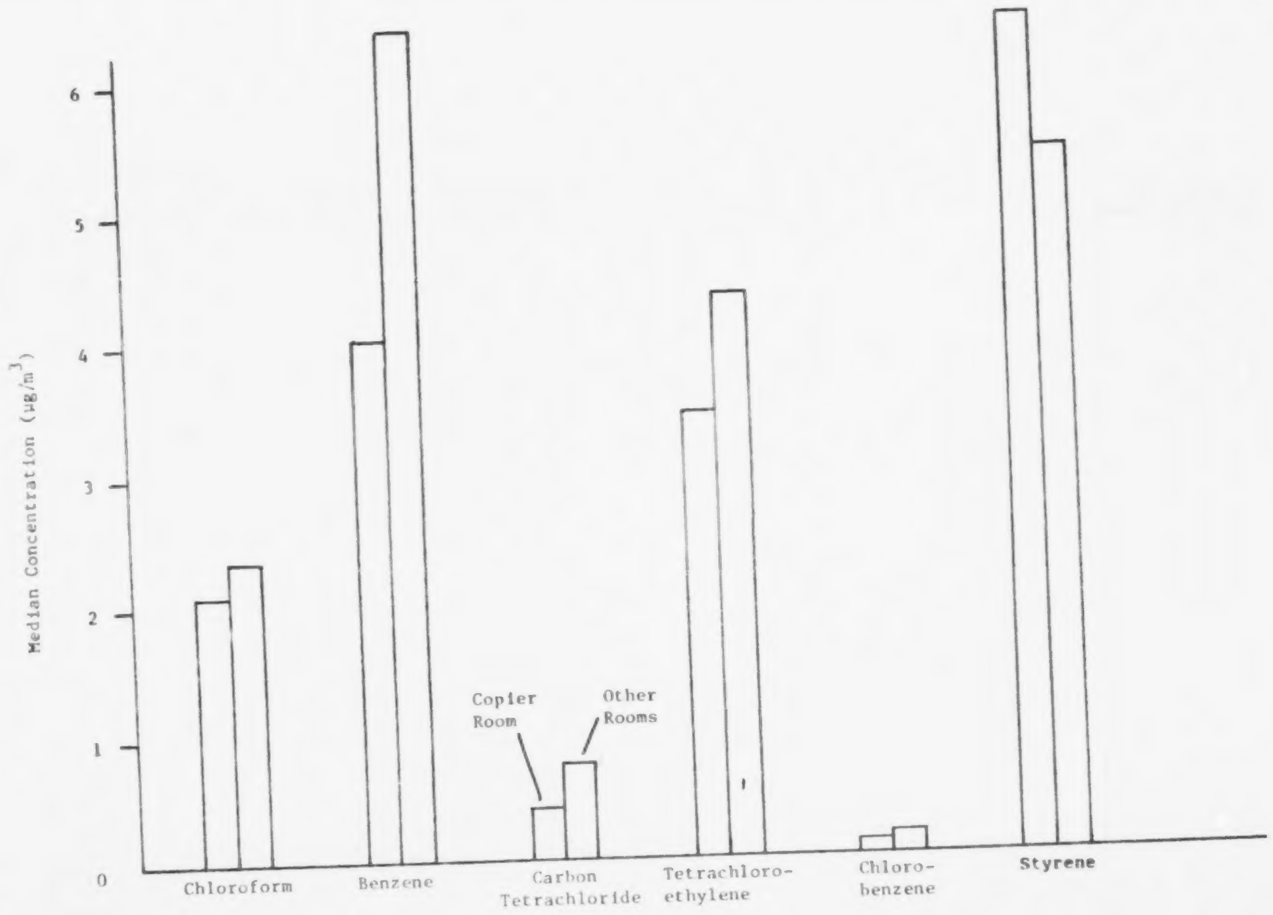

Figure 30. Median concentrations for all 3 trips to the office building - copier room vs. other rooms - daytime only.

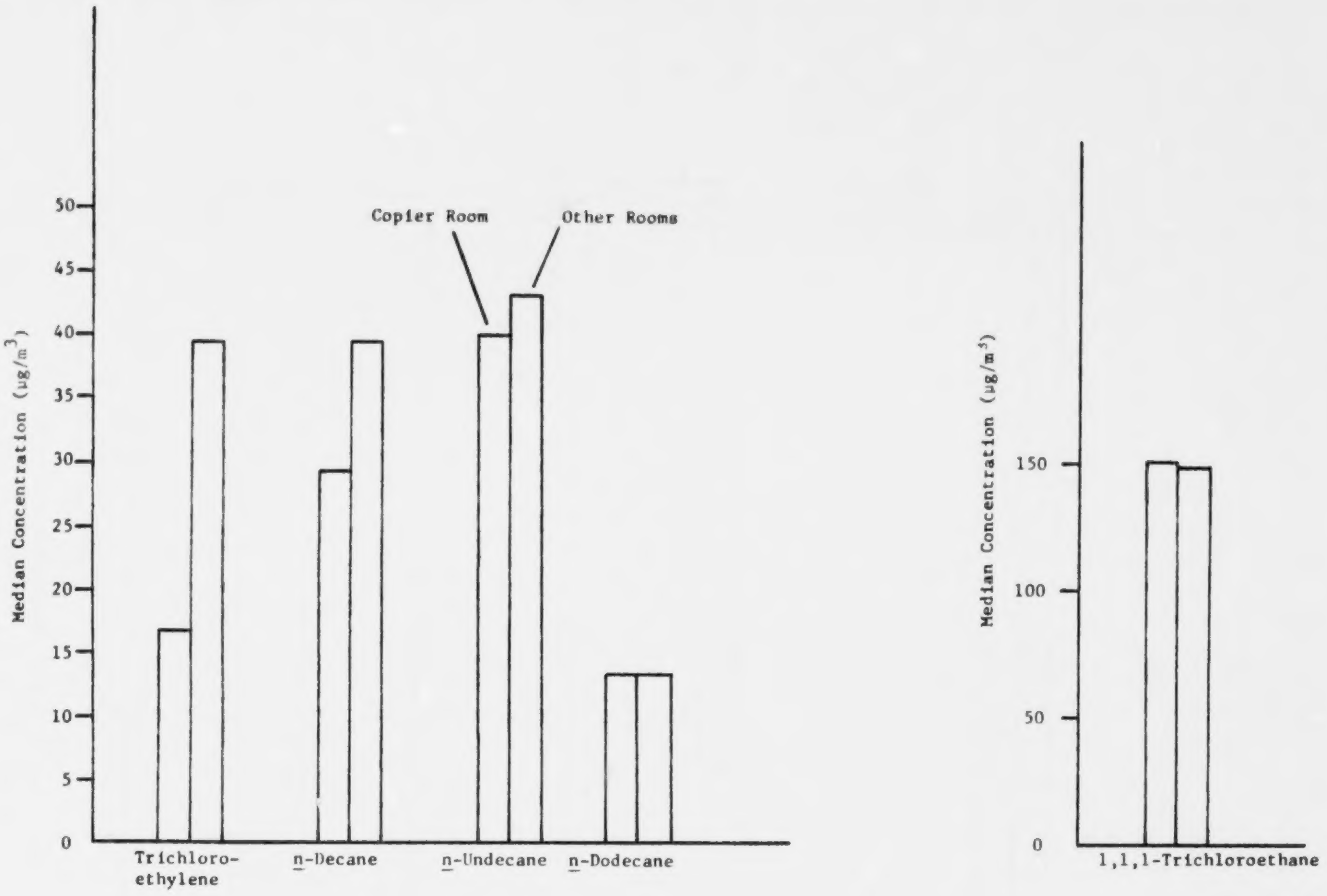

Figure 31. Median concentrations for all 3 trips to the office building - copier room vs. other rooms - daytime only.

TABLE 80. PERCENT MEASURABLE - VOLATILE ORGANICS - SCHOOL

Compound	Percent Measurable		Ratio (In/Out)
	Indoor (16-17)[a]	Outdoor (4-5)[a]	
Chloroform	17.6	60.0	0.3
1,1,1-Trichloroethane	100.0	100.0	1.0
Benzene	100.0	100.0	1.0
Carbon Tetrachloride	94.1	100.0	0.9
Trichloroethylene	100.0	80.0	1.3
Tetrachloroethylene	100.0	100.0	1.0
Chlorobenzene	37.5	20.0	1.1
Styrene	100.0	60.0	1.9
m,p-Dichlorobenzene	100.0	100.0	1.0
Ethylbenzene	100.0	100.0	1.0
o-Xylene	100.0	80.0	1.3
m,p-Xylene	100.0	100.0	1.0
n-Decane	100.0	100.0	1.0
n-Undecane	100.0	100.0	1.0
n-Dodecane	100.0	100.0	1.0

[a] Sample size range.

TABLE 81. PERCENT MEASURABLE - VOLATILE ORGANICS - ELDERLY HOME-1

	Percent Measurable		
Compound	Indoor (30)[a]	Outdoor (5-6)[a]	Ratio (In/Out)
Chloroform	100.0	100.0	1.0
1,2-Dichloroethane	25.0	83.3	0.3
1,1,1-Trichloroethane	100.0	100.0	1.0
Benzene	100.0	100.0	1.0
Carbon Tetrachloride	100.0	100.0	1.0
Trichloroethylene	86.7[b]	100.0	0.9
Tetrachloroethylene	100.0	100.0	1.0
Styrene	96.7	100.0	1.0
m,p-Dichlorobenzene	100.0	100.0	1.0
o-Dichlorobenzene	16.7	0.5	1.0
Ethylbenzene	100.0	100.0	1.0
o-Xylene	100.0	100.0	1.0
m,p-Xylene	100.0	100.0	1.0
1,1,2,2-Tetrachloroethane	16.7	32.3	0.5
n-Decane	100.0	100.0	1.0
n-Undecane	100.0	100.0	1.0
n-Dodecane	96.7	100.0	1.0

[a] Sample size range.

[b] Indicates a significant difference for t-test at 0.05 level between indoor versus outdoor air.

TABLE 82. PERCENT MEASURABLE - VOLATILE ORGANICS - ELDERLY HOME-2

Compound	Percent Measurable Indoor (22-23)[a]	 Outdoor (6)[a]	Ratio (In/Out)
Chloroform	100.0	100.0	1.0
1,1,1-Trichloroethane	100.0	100.0	1.0
Benzene	100.0	100.0	1.0
Carbon Tetrachloride	100.0	100.0	1.0
Trichloroethylene	78.3	83.3	0.9
Tetrachloroethylene	100.0	100.0	1.0
Styrene	40.9	50.0	0.8
m,p-Dichlorobenzene	90.9	100.0	0.9
Ethylbenzene	100.0	100.0	1.0
o-Xylene	95.5	100.0	1.0
m,p-Xylene	100.0	100.0	1.0
n-Decane	100.0	100.0	1.0
n-Undecane	100.0	100.0	1.0
n-Dodecane	100.0	100.0	1.0

[a] Sample size range in parenthesis.

chemicals the ratios for indoor versus outdoor percent measurable are close to one. Thirteen of the fourteen compounds have greater than 50% measurable for both indoor and outdoor locations for elderly home-2. The single exception is for styrene. Eleven of the ratios are 1.0.

There are very few differences among the three sites in terms of percent measurable. Most of the chemicals were 100% detected in both indoor and outdoor samples. The only significant difference based on a t-test was for trichloroethylene for elderly home-1, which was detected 100% of the time in the outdoor samples and only 86% of the time in indoor samples.

Tables E-19 to E-33 in Appendix E give concentration levels for volatile organics found at the three sites. Tables 83 through 85 summarize this information, giving average concentrations found at each location for each site. Tables 86 through 88 contain the summary statistics for the three sites for indoor and outdoor sample concentrations. For the school building, nine of the fifteen compounds were 100% detected. Two compounds had a significant difference at the 0.05 level based on an analysis of variance test performed on reported concentrations among the three indoor locations. There were no significant concentration differences between day and night or between indoor and outdoor mean concentration levels. Thus, there appears to be no real difference between the indoor and outdoor air samples. There are six median concentration ratios (indoor/outdoor) greater than one ranging from 2.1 (styrene) to 1.3 (*n*-undecane).

Table 87 shows the summary statistics for the elderly home-1 for indoor versus outdoor concentrations. Eleven of the fourteen compounds were detected in 100% of the samples. Only styrene (1.1) had a median indoor/outdoor concentration ratio greater than 1.0. Seven of the maximum indoor/outdoor concentration ratios were greater than one. Generally, the outdoor concentrations for means, medians, and maximums were larger than the indoor concentration; however, when a paired t-test was performed for this difference only *m,p*-dichlorobenzene and *n*-dodecane showed a significant difference at the 0.05 level. Nine compounds showed a significant concentration difference between day and night with highest concentrations found during the day. Eleven of the fourteen showed a significant concentration difference based on a test for differences among the four indoor locations.

TABLE 83. AVERAGE CONCENTRATION OF VOLATILE ORGANICS FOUND AT THE SCHOOL

Compound	Average Concentration ($\mu g/m^3$)			
	Ground Floor Common Area	2nd Floor Near Stairway	4th Floor Near Stairway	Outdoor
Chloroform	0.08	0.04	0.29	0.88
1,2-Dichloroethane	0.03	0.05	0.02	0.09
1,1,1-Trichloroethane	29.0	22.0	17.0	7.4
Benzene	8.5	12.0	6.3	11.
Carbon Tetrachloride	0.82	0.97	0.71	0.92
Trichloroethylene	0.93	0.81	0.61	0.60
Tetrachloroethylene	5.0	7.8	6.5	3.69
Chlorobenzene	0.17	0.24	0.11	0.12
Styrene	3.2	1.5	0.98	1.57
m,*p*-Dichlorobenzene	1.6	2.2	2.1	3.0
o-Dichlorobenzene	0.13	0.10	0.11	0.09
Ethylbenzene	4.6	4.1	1.7	5.6
o-Xylene	5.9	4.2	4.2	5.8
m,*p*-Xylene	13.0	11.0	5.6	14.
1,1,2,2-Tetrachloroethane	0.02	0.02	0.02	0.02
n-Decane	0.89	0.61	1.1	0.72
n-Undecane	0.88	0.69	0.92	0.96
n-Dodecane	0.75	0.83	0.72	0.93

TABLE 84. AVERAGE CONCENTRATION OF VOLATILE ORGANICS FOUND AT THE ELDERLY HOME-1

Compound	Average Concentration ($\mu g/m^3$)					
	5th Floor Lounge	3rd Floor Smoker's Lounge	Dining Room	4th Floor Apartment	1st Floor Smoker's Apartment	Outdoors
Chloroform	2.0	1.7	1.4	2.2	2.3	0.84
1,2-Dichloroethane	0.09	0.08	0.4	0.08	0.21	0.59
1,1,1-Trichloroethane	32.0	28.0	24.0	61.0	16.0	14.0
Benzene	12.0	12.0	10.0	18.0	12.0	10.0
Carbon Tetrachloride	0.73	0.69	0.79	0.72	0.64	0.67
Trichloroethylene	0.90	0.86	0.30	0.73	0.21	0.32
Tetrachloroethylene	3.7	3.3	2.7	2.7	1.4	2.5
Chlorobenzene	0.13	0.14	0.10	0.14	0.08	0.12
Styrene	1.1	1.7	2.5	1.5	2.0	1.03
m,p-Dichlorobenzene	4.5	8.2	2.2	6.1	2.7	1.9
o-Dichlorobenzene	0.11	0.14	0.21	0.24	0.13	0.11
Ethylbenzene	3.7	3.8	2.5	3.7	4.1	1.6
o-Xylene	3.2	3.3	2.6	3.9	4.3	1.7
m,p-Xylene	9.6	9.7	6.6	9.3	11.0	4.2
1,1,2,2-Tetrachloroethane	0.21	0.03	0.17	0.04	0.56	0.27
n-Decane	19.0	20.0	6.2	32.0	87.0	3.3
n-Undecane	18.0	18.0	7.4	22.0	68.0	2.3
n-Dodecane	5.6	5.9	2.4	13.0	13.0	0.81

TABLE 85. AVERAGE CONCENTRATION OF VOLATILE ORGANICS FOUND AT THE ELDERLY HOME-2

Compound	Average Concentration ($\mu g/m^3$)				
	1st Floor Common Area	3rd Floor Nonsmoker's Apt.	5th Floor Unoccupied Apt.	8th Floor Smoker's Apt.	Outdoors
Chloroform	1.2	3.8	1.2	2.2	0.90
1,2-Dichloroethane	0.12	0.13	0.17	0.15	0.12
1,1,1-Trichloroethane	21.0	5.2	5.0	44.0	3.2
Benzene	7.0	6.7	8.2	11.6	5.44
Carbon Tetrachloride	1.3	1.6	1.6	1.7	1.4
Trichloroethylene	0.64	0.65	0.8	0.89	0.55
Tetrachloroethylene	4.1	4.9	5.0	4.7	2.12
Chlorobenzene	0.05	0.07	0.06	0.13	0.04
Styrene	2.0	1.3	0.73	1.4	0.02
m,p-Dichlorobenzene	0.74	3.2	0.56	0.90	0.26
o-Dichlorobenzene	0.13	0.07	0.07	0.08	0.04
Ethylbenzene	6.6	4.5	4.7	6.1	2.3
o-Xylene	6.5	2.7	4.9	5.7	2.4
m,p-Xylene	16.0	11.0	12.0	14.0	5.9
1,1,2,2-Tetrachoroethane	0.03	0.05	0.02	0.03	0.02
n-Decane	3.4	1.7	2.0	3.5	0.80
n-Undecane	3.1	1.7	2.1	3.3	0.62
n-Dodecane	3.4	0.94	1.6	2.7	0.32

TABLE 86. SUMMARY STATISTICS - VOLATILE ORGANICS - SCHOOL[a]

Compound	Median QL	Concentration (μg/m^3) Mean Indoor	Mean Outdoor	Median Indoor	Median Outdoor	Max Indoor	Max Outdoor	Median (In/Out)	Max (In/Out)
Chloroform	0.18	0.13[c]	0.88	0.03	0.14	0.54	2.2	0.2	0.2
1,1,1-Trichloroethane	0.15[b]	23.	7.4	11.	7.7	120.	14.	1.4	1.4
Benzene	0.15[b]	9.2[c]	11.	9.5	11.	16.	14.	0.8	0.9
Carbon Tetrachloride	0.22	0.84	0.92	0.69	0.86	2.4	1.5	0.9	0.8
Trichloroethylene	0.07	0.79	0.60	0.74	0.60	1.8	1.2	1.2	1.2
Tetrachloroethylene	0.15[b]	6.4	3.6	4.8	2.7	18.	6.3	1.8	1.8
Chlorobenzene	0.07	0.18	0.12	0.11	0.11	0.64	0.22	1.0	1.0
Styrene	0.08	2.0	1.5	1.5	1.2	5.5	3.4	1.3	1.3
m,p-Dichlorobenzene	0.15[b]	1.9	3.0	1.5	1.3	5.5	6.6	1.2	1.2
Ethylbenzene	0.15[b]	3.7	5.0	2.7	7.7	14.	11.	0.4	0.4
o-Xylene	0.19	4.8	5.8	4.8	7.8	15.	12.	0.6	0.6
m,p-Xylene	0.15[b]	10.	14.	7.9	20.0	35.	26.	0.4	0.4
n-Decane	0.15[b]	0.83	0.72	0.72	0.53	1.8	1.7	1.4	1.4
n-Undecane	0.15[b]	0.82	0.96	0.82	0.63	1.6	2.3	1.3	1.3
n-Dodecane	0.15[b]	0.77	0.93	0.71	0.76	1.4	1.5	0.9	0.9

[a] Indoor sample size was 16-17; outdoor sample size was 5-6.

[b] Compounds were 100% detected, estimated QL.

[c] Indicates a significant difference at 0.05 level when performing analysis of variance test for differences among the three indoor locations.

Table 87. Summary Statistics - Volatile Organics Elderly Home 1[a] Concentrations ($\mu g/m^3$)

Compound	Median QL	Mean		Median		Max		Ratio	
		Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Median (In/Out)	Max (In/Out)
Chloroform	0.15^{b}	$1.9^{c,e}$	0.84	1.7	0.76	3.9	1.4	2.2	2.8
1,1,1, Trichloroethane	0.15^{b}	$32.^{e}$	14.	26.	12.	140.	27.	2.2	5.2
Benzene	0.15^{b}	$13.^{c}$	10.	12.	8.6	47.	15.	1.4	3.1
Carbontetrachloride	0.15^{b}	0.71^{c}	0.70	0.72	0.72	1.0	0.76	1.0	1.3
Trichloroethylene	0.08	$0.60^{d,e}$	0.32	0.53	0.30	2.0	0.55	1.8	3.6
Tetrachloroethylene	0.15^{b}	7.6	2.5	3.0	2.4	110.	4.7	1.3	23.4
Styrene	0.17	1.7^{c}	1.0	1.8	0.55	4.0	3.8	3.3	1.1
m-p-Dichlorobenzene	0.15^{b}	$4.7^{d,e}$	1.9	4.2	1.8	10.	3.0	2.3	3.3
Ethylbenzene	0.15^{b}	$3.6^{c,e}$	1.6	3.3	1.8	7.0	2.4	1.8	2.9
O-Xylene	0.15^{b}	$3.4^{c,e}$	1.7	3.3	1.9	7.4	2.3	1.7	3.2
m-p Xylene	0.15^{b}	$9.3^{c,e}$	4.2	8.4	4.7	18.	6.1	1.8	3.0
n-Decane	0.15^{b}	$33.^{d,e}$	3.3	21.	3.5	180.	4.5	6.0	40.
n-Undecane	0.15^{b}	$27.^{d,e}$	2.2	18.	2.4	140.	3.1	7.5	45.
n-Dodecane	0.07	$7.9^{d,e}$	0.8	6.9	0.8	19.	1.3	8.6	14.

[a] Indoor sample size was 30; Outdoor sample size was 6.

[b] Compounds were 100% detected, estimated QL.

[c] Indicates a significant difference at 0.05 level when performing analysis of variance test for differences between day and night, with day levels being higher.

[d] Indicates a significant difference at 0.05 level when performing analysis of variance test for differences among the 5 indoor locations.

[e] Indicates a significant difference at 0.05 level when performing a paired t-test for difference in indoor versus outdoor concentrations as shown.

Table 88. Summary Statistics - Volatile Organics Elderly Home 2[a] Concentrations ($\mu g/m^3$)

Compound	Median QL	Mean		Median		Max		Ratio	
		Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Median (In/Out)	Max (In/Out)
Chloroform	0.15[b]	2.1[d]	1.0	1.8	0.62	4.9	2.1	2.9	2.3
1,1,1, Trichloroethane	0.15[b]	19.	3.2	6.0	1.5	220.	7.4	4.0	29.7
Benzene	0.15[b]	8.4	5.4	7.4	4.6	17.	11.	1.6	1.5
Carbontetrachloride	0.15[b]	1.5	1.4	1.4	0.53	2.7	2.9	2.6	0.9
Trichloroethylene	0.16	0.74	0.55	0.81	0.24	1.2	1.4	3.4	0.9
Tetrachloroethylene	0.15[b]	4.6[c,e]	2.1	2.6	2.1	14.	3.6	1.2	3.9
Styrene	0.20	1.4[e]	0.02	0.25	0.02	11.	0.03	12.5	360.
m-p-Dichlorobenzene	0.07	1.3[d,e]	0.26	0.80	0.29	4.1	0.46	2.8	8.9
Ethylbenzene	0.15[b]	5.5[e]	2.3	4.1	2.4	15.	3.4	1.7	4.4
O-Xylene	0.20	5.0[e]	2.4	3.8	2.3	15.	3.4	1.7	4.4
m-p Xylene	0.15[b]	13.[e]	5.9	11.	6.2	36.	8.3	1.8	4.3
n-Decane	0.15[b]	2.7,[e]	0.80	2.3	0.86	6.8	1.2	2.7	5.7
n-Undecane	0.15[b]	2.6,[e]	0.62	2.3	0.75	5.9	0.90	3.1	6.6
n-Dodecane	0.15[b]	2.1[d,e]	0.32	1.9	0.33	4.3	0.51	5.8	8.4

[a] Indoor sample size was 23-24; Outdoor sample size was 5.

[b] Compounds were 100% detected, estimated QL.

[c] Indicates a significant difference at 0.05 level when performing analysis of variance test for differences between day and night, with day levels being higher.

[d] Indicates a significant difference at 0.05 level when performing analysis of variance test for differences among the 4 indoor locations.

[e] Indicates a significant difference at 0.05 level when performing a paired t-test for difference in indoor versus outdoor concentrations as shown.

Table 88 shows the summary statistics for the elderly home-2 for indoor versus outdoor sample concentrations. Ten of the compounds were 100% detected. Four compounds - chloroform, n-decane, n-undecane and n-dodecane - showed a significant difference using a paired t-test in indoor versus outdoor concentration. Chloroform concentrations were higher indoors, whereas the alkane concentrations were higher outdoors. Only tetrachloroethylene showed a significant difference between day and night concentrations with day concentrations higher. Eight compounds showed a significant difference when tested for a difference among the five indoor locations. Again, the indoor and outdoor air samples are very similar in concentration.

Figures 32 and 33 show the median indoor concentrations for volatile organics in the school and elderly homes-1 and 2 combined by day versus night. For most compounds daytime concentrations are higher, suggesting that volatile organics are probably being released into the air from daytime activities. Some activities which may be responsible for their occurrence are cleaning supplies, smoking, and cooking.

Summary and Comparisons

Tables 89 and 90, and Figures 34 and 35 were prepared in order to show that the office building trip 1 indoor air samples had the highest concentrations of volatile organics and that the third trip levels were considerably reduced and that the other buildings had even lower concentrations. Table 89 compares the mean, median and maximum concentrations for trip 1 to the office building to the other buildings for indoor air and Table 90 compares the office building indoor air concentrations for trip 3 to the other buildings. Thus, using the concentration statistics of the other buildings as a standard, the median concentration ratios were generally greatly reduced between trip 1 to trip 3 to the office building. The median ratio for n-decane went from 120 to 1.5, for n-undecane from 67 to 4.3, and for n-dodecane from 31 to 2.8.

Figures 34 and 35 show the above results even more graphically. 1,1,1-Trichloroethane, m,p-xylene, n-ethylbenzene, n-decane, n-undecane, o-xylene, and n-dodecane levels are much higher for office building trip 1 compared to either trip 3 or the other buildings combined. In all cases, except for n-dodecane, median concentrations for time period 1 (overnight) were less

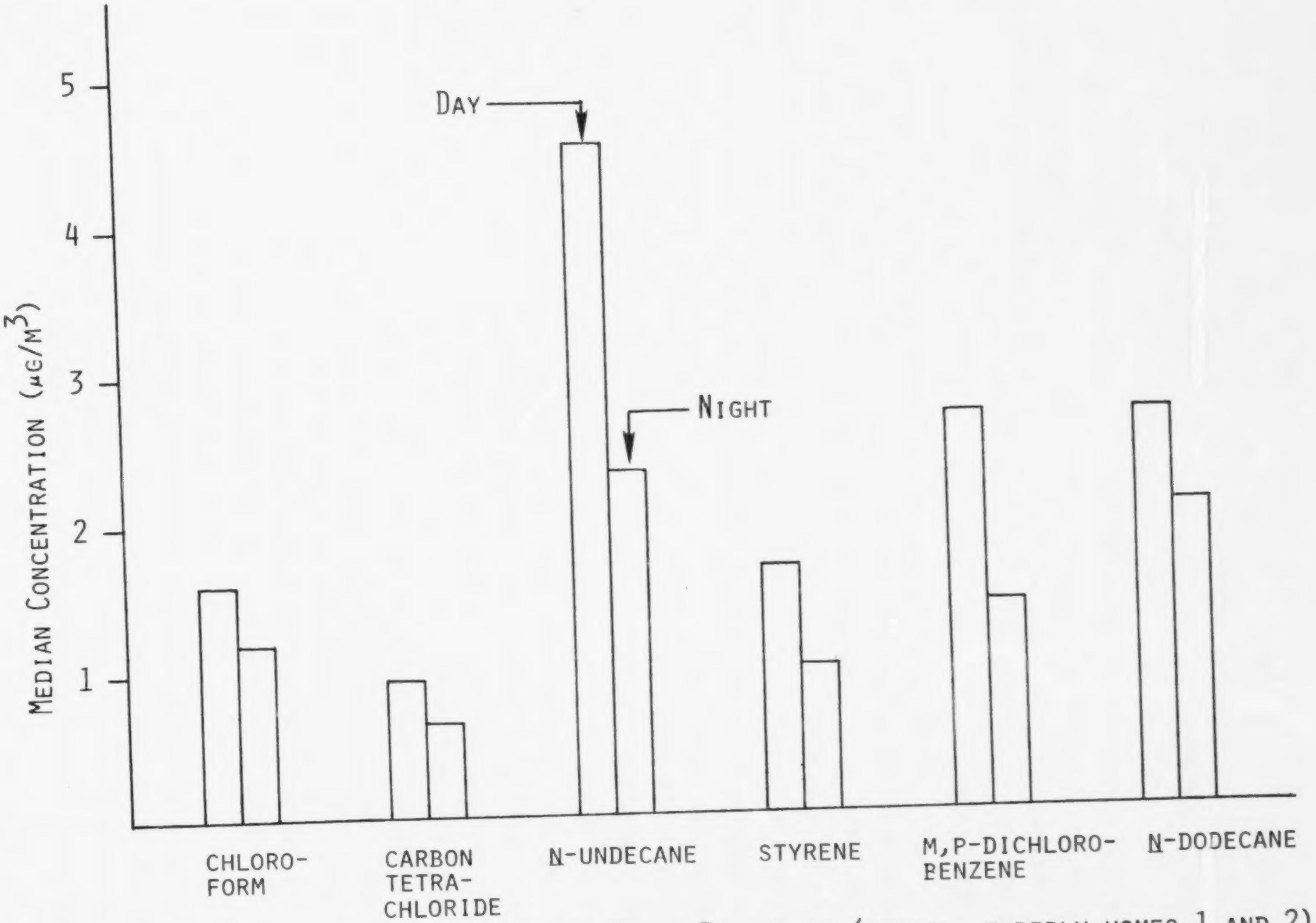

FIGURE 32. MEDIAN CONCENTRATION FOR OTHER BUILDINGS (SCHOOL, ELDERLY HOMES 1 AND 2) DAY VS. NIGHT - INDOORS ONLY.

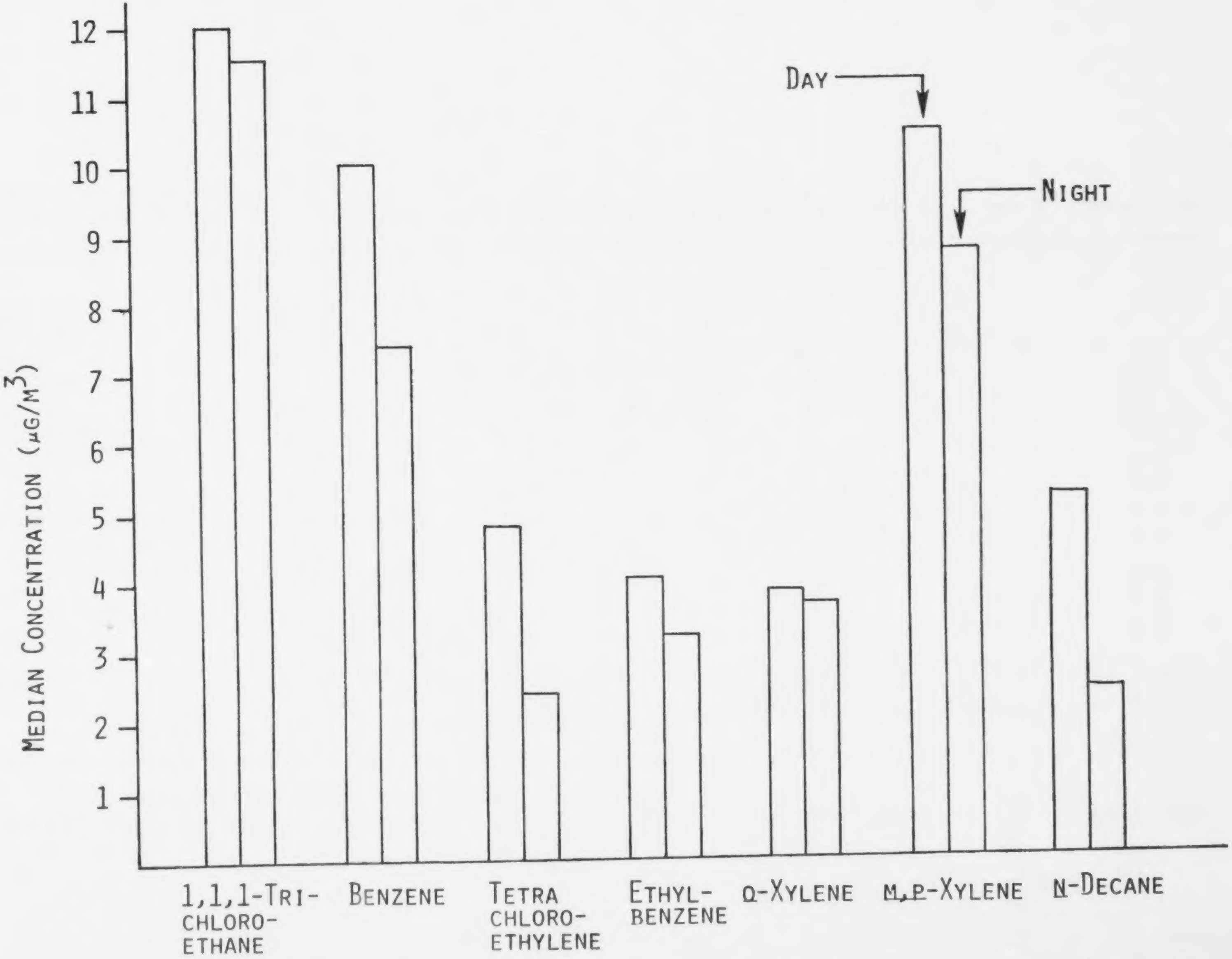

FIGURE 33. MEDIAN CONCENTRATIONS FOR OTHER BUILDINGS (SCHOOL, ELDERLY HOMES 1 AND 2) DAY VS. NIGHT - INDOORS ONLY

TABLE 89. SUMMARY STATISTICS - VOLATILE ORGANICS INDOOR ONLY - OFFICE BUILDING TRIP 1 VS. OTHER BUILDINGS (SCHOOL, ELDERLY HOMES 1 AND 2) (Revised November 1987)

Compound[a]	Concentrations ($\mu g/m^3$)						Ratio	
	Mean		Median		Max		Median	Max
	Trip 1	Other	Trip 1	Other	Trip 1	Other	Trip 1/Other	Trip 1/Other
Chloroform	0.88	1.5	0.81	1.5	3.3	4.9	0.5	0.7
1,1,1-Trichloroethane	380.	26.	290.	12.	870.	220.	24.	4.0
Benzene	4.6	10.	4.7	9.5	8.5	47.	0.5	0.2
Carbon Tetrachloride	0.44	1.0	0.08	0.82	2.9	2.7	0.1	1.1
Trichloroethylene	1.2	0.69	1.1	0.66	3.6	2.0	1.7	1.8
Tetrachloroethylene	6.7	6.4	4.6	3.2	17.	110.	1.4	0.2
Chlorobenzene	0.11	0.12	0.02	0.11	1.8	0.64	0.2	2.8
Styrene	8.3	1.7	8.6	1.4	18.	11.	6.1	1.6
m,p-Dichlorobenzene	1.4	2.9	1.1	1.8	9.6	10.	0.6	1.0
Ethylbenzene	84.	4.2	82.	3.6	200.	15.	23.	13.
o-Xylene	74.	4.3	54.	3.6	340.	15.	15.	23.
m,p-Xylene	140.	11.	150.	9.4	340.	36.	16.	9.4
n-Decane	380.	15.	310.	3.6	780.	180.	86.	4.3
n-Undecane	170.	13.	150.	3.3	320.	140.	45.	2.3
n-Dodecane	47.	4.3	44.	2.5	110.	19.	18.	5.8

---

[a] Sample size for Trip 1 was 20 except for n-decane, n-undecane, and n-dodecane which was 9; sample size Other Buildings was 69-71.

TABLE 90. SUMMARY STATISTICS - VOLATILE ORGANICS INDOOR ONLY - OFFICE BUILDING TRIP 3 VS. OTHER BUILDINGS (SCHOOL, ELDERLY HOMES 1 AND 2) (Revised November 1987)

	Concentrations (μg/m^3)						Ratio	
	Mean		Median		Max		Median	Max
Compound[a]	Trip 1	Other	Trip 1	Other	Trip 1	Other	Trip 1/Other	Trip 1/Other
Chloroform	18.	1.5	13.	1.5	110.	4.9	8.7	22.
1,1,1-Trichloroethane	49.	26.	41.	12.	170.	220.	3.4	0.8
Benzene	6.6	10.	3.6	9.5	25.	47.	0.4	0.5
Carbon Tetrachloride	0.86	1.0	0.76	0.82	3.1	2.7	0.9	1.1
Trichloroethylene	27.	0.69	25.	0.66	51.	2.0	38.	26.
Tetrachloroethylene	3.0	6.4	1.7	3.2	8.6	110.	0.5	0.1
Chlorobenzene	0.21	0.10	0.14	0.11	0.67	0.64	1.3	1.0
Styrene	3.8	1.7	3.4	1.4	7.5	11.	2.4	0.7
m,p-Dichlorobenzene	0.56	2.9	0.50	1.8	1.4	10.	0.3	0.1
Ethylbenzene	4.8	4.2	4.5	3.6	11.	15.	1.3	0.7
o-Xylene	3.5	4.3	3.2	3.6	7.2	15.	0.9	0.5
m,p-Xylene	9.0	11.	8.2	9.4	18.	36.	0.9	0.5
n-Decane	4.4	15.	4.1	3.6	11.	180.	1.1	0.1
n-Undecane	13.	13.	9.7	3.3	37.	140.	2.9	0.3
n-Dodecane	4.6	4.3	3.9	2.5	10.	19.	1.6	0.5

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a/ Sample size for Trip 3 was 19-20; sample size for Other Buildings was 69-71.

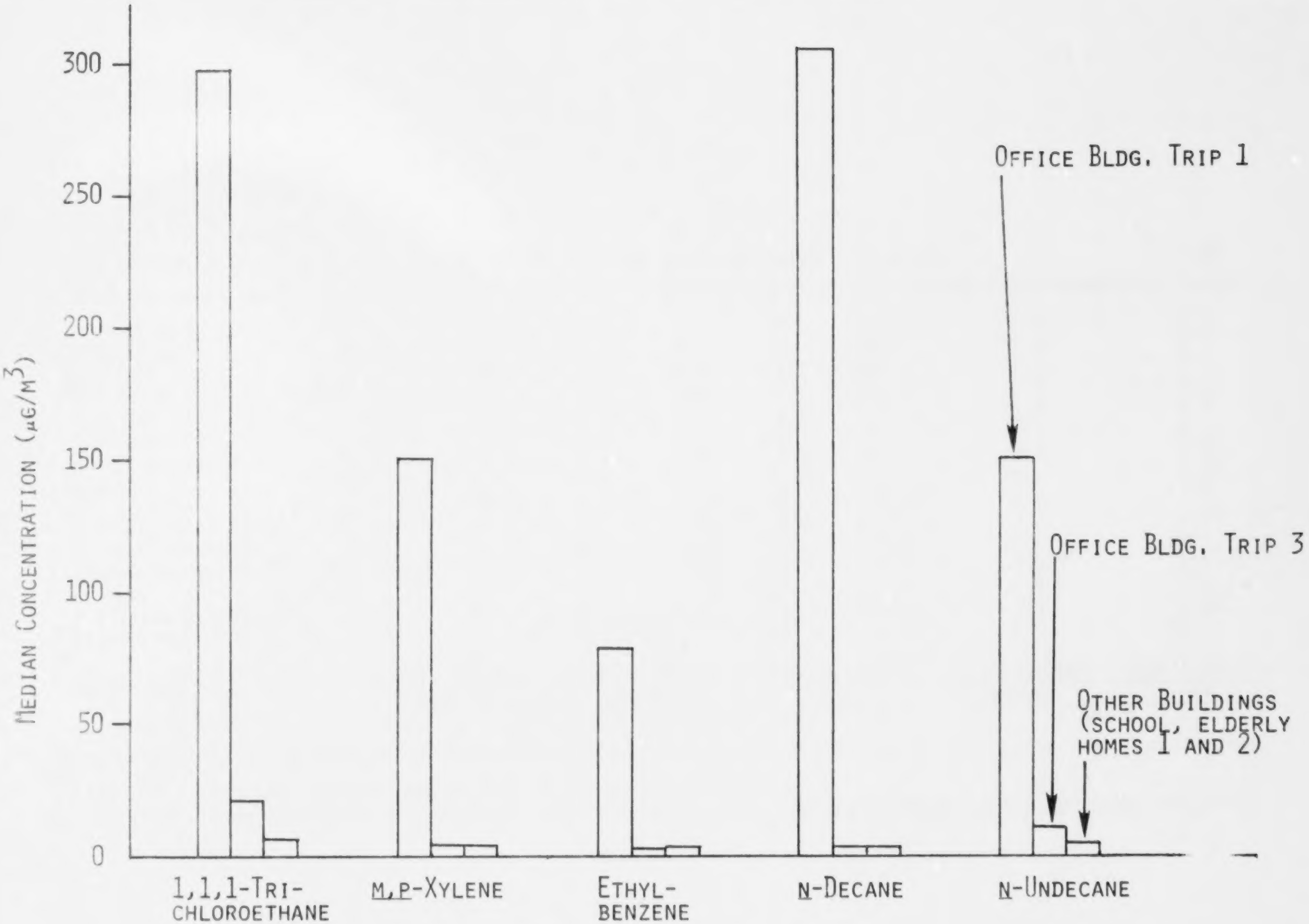


FIGURE 34. VOLATILE ORGANICS INDOOR MEDIAN CONCENTRATION DISTRIBUTION BY TRIP AND SITE.

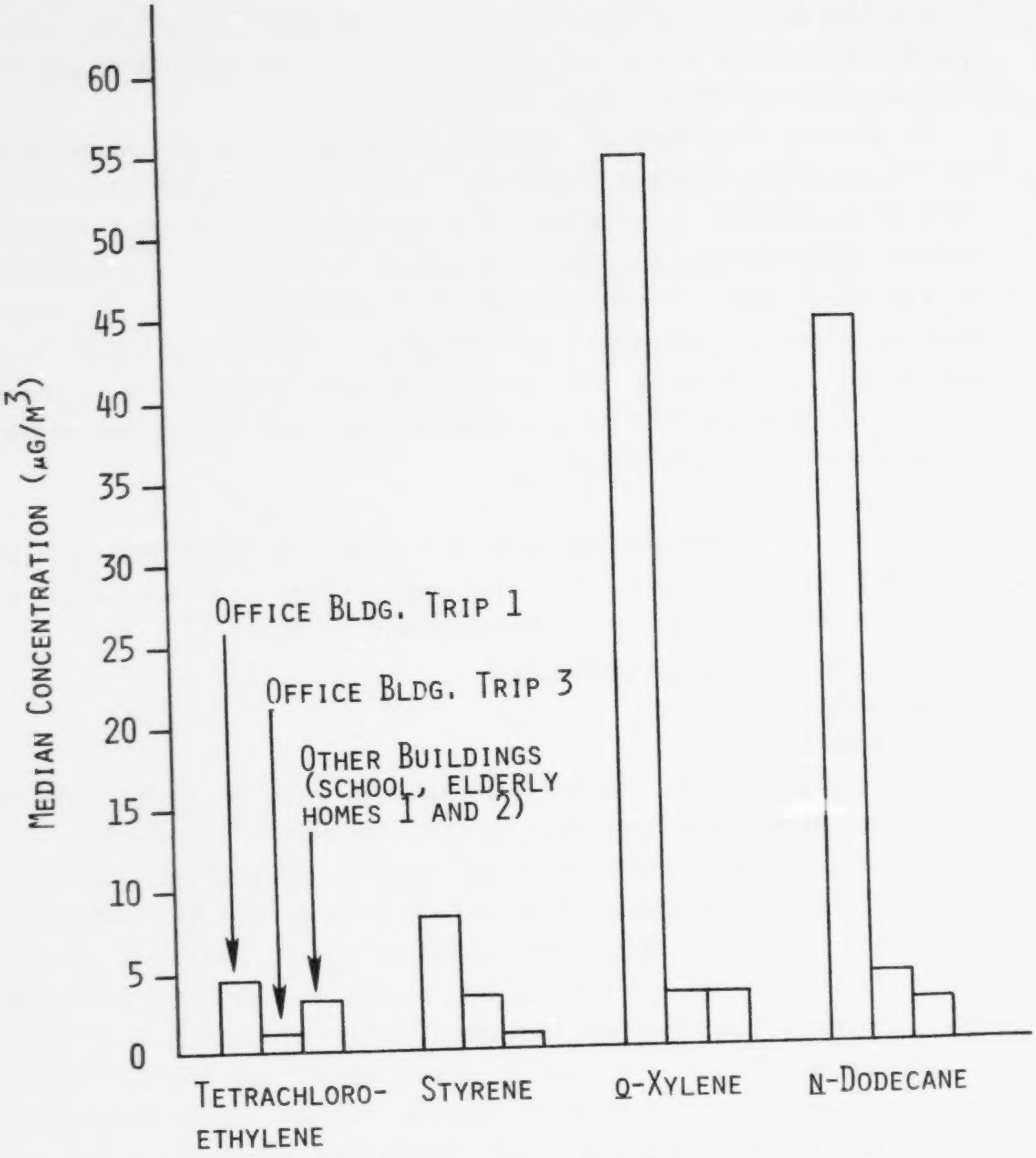


Figure 35. Volative Organics Indoor Median Concentration Distributions by Trip and Site

than the overall median for trip 1. As discussed previously, hydrocarbon-based furniture cleaners had been used during this time period which were probably responsible for the high concentrations of many volatile organics throughout the building under these conditions. Time period 1 probably gives the best representation of volatile organics in a new building. Even if only time period 1 is considered, the indoor concentrations for volatile organics during trip 1 to the office building are higher than any other trips or other buildings, singly or combined.

In general, for indoor air samples there was a high percent measurable for fifteen of the eighteen chemicals. For the office building, for the three trips combined, percent measurable was 100% for 1,1,1-trichloroethane, benzene, ethylbenzene, o-xylene, m,p-xylene, n-undecane, and n-dodecane. For the school, percent measurable was 100% indoors for all of the volatile organics except chloroform and chlorobenzene. For elderly home-1, it was 100% for all volatiles except trichloroethylene, styrene, and n-dodecane. The same was true for elderly home-2 except for trichloroethylene, styrene, m,p-dichlorobenzene, and o-xylene.

FORMALDEHYDE

Results of formaldehyde analysis are given in Table 91. Data show detectable concentrations at only a few sampling sites. No conclusions were drawn from these results due to limited amounts of data.

INHALABLE AND RESPIRABLE PARTICULATE

Piezobalance

Elderly Home 1-

Duplicate monitoring with two Piezobalances resulted in small absolute differences in measured respirable particulate levels but relatively large percentage differences at the low levels encountered (Table 92). Unfortunately, no high levels (> 50 $\mu g/m^3$) of respirable particulates were encountered on the day both monitors were employed; therefore reproducibility at high levels could not be tested. The primary instrument showed generally lower readings than the secondary instrument, both with and without the HEPA filter. Nonsmoking areas showed uniformly low levels of respirable particulate (10-20 $\mu g/m^3$) during all 800 minutes of monitoring (Table 93). Although respirable particulate concentration in the smoking areas occasionally approached these low levels after extended periods

TABLE 91. RESULTS OF FORMALDEHYDE ANALYSIS

Sample[a]	Concentration[b] (ppb)					
	Elderly home-1	School	Office-1	Office-2	Office-3	Elderly home-2
Site 1						
Day 1	NC[b]	ND[c]	SL[d]	Trace	ND	ND
Day 2	ND	ND	SL	ND	ND	ND
Day 3	ND	ND	--[e]	--	--	ND
Site 2						
Day 1	164	ND	SL	42,trace[f]	ND	ND
Day 2	ND	ND	SL	--	ND[f]	ND[f]
Day 3	ND	ND	--	--	--	ND
Site 3						
Day 1	323[f]	ND	SL	49	ND	ND
Day 2	ND	ND	SL	Trace	ND	ND
Day 3	ND	ND[f]	--	--	--	ND
Site 4						
Day 1	Trace	ND	SL	ND	ND	ND[f]
Day 2	ND[f]	ND[f]	SL	Trace,ND	ND	ND
Day 3	ND	ND	--	--	--	ND
Site 5						
Day 1	ND	--	SL	ND	ND	ND
Day 2	ND	--	SL	Trace	ND[f]	ND
Day 3	ND	--	--	--	--	ND

(continued)

TABLE 91. (cont'd.)

Sample[a]	Concentration[b] (ppb)					
	Elderly home-1	School	Office-1	Office-2	Office-3	Elderly home-2
Site 6						
Day 1	648	--	SL	Trace	ND	--
Day 2	58	--	SL	Trace	ND	--
Day 3	Trace	--	--	--	--	--

[a] For definition of sample sites see Tables 5,12,15 and 19.

[b] Sample not collected.

[c] Home-1 ND = 3.9 ppb Trace = 5.4 ppb
School: ND = 9.4 ppb Trace = 12 ppb
Office-2: ND = 3.6 ppb Trace = 4.7 ppb
Office-3: ND = 2.2 ppb Trace = 2.34 ppb
Home-2: ND = 17.42 ppb Trace = 25 ppb

[d] Samples lost during analysis.

[e] Sample not scheduled for collection.

[f] Results of duplicate analysis.

TABLE 92. SIDE-BY-SIDE READINGS OF TWO PEIZOBALANCE INSTRUMENTS IN ELDERLY HOME-1

		Instrument #1 Reading[a]		Instrument #2 Reading[a]	
Location	Time Period	Raw	Corrected[b]	Raw	Corrected
Administrator's Office	11:18-11:43 AM	15[a]	15	42	36
	12:00-12:11 PM	14	14	27	21
Dining Room	12:31-12:35 PM	12	12	17	5
3rd-Floor Lounge	1:04-1:18 PM	16	10	22	10
5th-Floor Lounge	1:47-2:02 PM	9	8	18	10
Outside	2:36-3:04 PM	9[c]	9[c]	9	9

[a] Concentration in μg/m^3.

[b] Corrected for baseline drift and/or nonzero readings with HEPA filter attached.

[c] Did not come to temperature equilibrium.

TABLE 93. RESPIRABLE PARTICULATES - NONSMOKING AREAS - ELDERLY HOME-1

Date	Location	Total Time Measured[a]	Mean Concentration[b,c]	Range[b,c]
3/22	Administrator's Office	295	8	7-10
3/22	Administrator's Office	134	14	11-29
3/24	Administrator's Office	171	18	18-23
3/25	Administrator's Office	53	15	14-15
3/24	5th Floor Lounge	24	13[d]	-[d]
	Room 439	10	13[d]	-
	Hallway in Basement	7	11[d]	-
	Dining Room	10	12[d]	-
3/25	5th Floor Lounge	14	8	-
	Dining Room	22	13	-
	Outside (5th Floor)	59	9[d]	-

[a] Minutes.

[b] $\mu g/m^3$.

[c] Uncorrected readings.

[d] Only one measurement.

without smoking, the concentrations were more often in the 40-60 $\mu g/m^3$ range with short-term peaks as high as 300 $\mu g/m^3$ (Tables 94 and 95). In the smoking areas, a clear source-effect relationship could be observed between observed concentrations and the number of smokers (Figure 36) or the actual times cigarettes were lit and extinguished (Figures 37 and 38). On two occasions, sufficient time passed without smoking to allow a calculation of the effective air exchange rates (Figures 39 and 40). These rates, which include deposition and plate-out effects, were calculated as 4.8 and 3.2 effective air changes per hour. Of course, the actual air exchange rate would be smaller in each case. The measured exchange rate using SF_6 tracers for the 3rd floor lounge was 2.3 compared to the effective rate of 4.8 as measured by the Piezobalance. All the readings in nonsmoking areas fell into a narrow range of 7-23 $\mu g/m^3$ for the same time period. This range is very similar to the range of 5-15 $\mu g/m^3$ for overnight and weekend respirable concentrations reported by Quant, Nelson and Sem(8-1), who used an automatic version of the piezobalance to measure concentrations in an office. Somewhat higher values of 20-30 $\mu g/m^3$ were reported for homes of nonsmokers in Topeka, KN(8-2), using a filter system with a 50% cutoff at 3.5 mm. In contrast to the narrow range of concentrations observed in all nonsmoking areas, the smoking areas displayed a wide range of respirable particulate concentrations ranging from 20-350 $\mu g/m^3$. A clear dependence on the number of smokers was noted, with values of 20-25 $\mu g/m^3$ when no smokers were present, 80-90 $\mu g/m^3$ with three smokers, and 280-350 $\mu g/m^3$ with nine smokers. These values correspond to an average contribution of 20-30 $\mu g/m^3$ per smoker in a large room (18' x 27') with two double doors open to the hallways. In the same room, a total of 4 cigarettes smoked over a period of one hour was sufficient to raise the concentration from 20 $\mu g/m^3$ to a one-hour average value of 60 $\mu g/m^3$, or the equivalent of 10 $\mu g/m^3$ per hour per cigarette. These calculations agree provided each smoker averages 2-3 cigarettes per hour, which correspond to about two packs a day. This is slightly higher than the average rate of smoking (32 cigarettes a day) in the U.S.

The observed values of 30-110 $\mu g/m^3$ for 1-3 smokers may be compared to the values of 37-89 $\mu g/m^3$ for three somewhat larger offices containing 1-3 smokers(8-3).

TABLE 94. PIEZOBALANCE RESULTS - ELDERLY HOME-1

Date	Location	Start Time	End Time	Concentration[a]	Baseline Drift[a]	HEPA Reading[a]	Corrected Reading[a]	Comments
3/22	Administrator's Office	1215	1219		0			No smoking in this office
		1219	1221	10			10	
		1221	1236	7			7	
		1254	1323		3		7	
		1324	1425	18				
		1428	1430		0			
		1431	1537			11		
		1537	1621	20			9	
		1621	1632	20			9	
		1633	1650			11		
		1651	1710	18			7	
3/23		0902	0917		-2			
		0919	0943	9			11	
		0946	1007			0		
		1009	1018	18			18	
		1655	1710	12				
		1710	1723	29				
3/24		0857	0953		-3			
		0954	0958	20			23	
		1452	1556		4			
		1556	1627	22			18	
		1632	1642			4		

(continued)

TABLE 94. (cont'd.)

Date	Location	Start Time	End Time	Concentration	Baseline Drift	HEPA Reading	Corrected Reading	Comments
3/24	2nd-Floor Lounge	1003	1005	50				Cigarette lit 10:05
			1007	100				out 10:10
			1009	50				
			1011	61				
			1013	61				
			1015	82				
			1018	95				Cigarette lit 10:19
			1020	78				out 10:25
			1022	69				
			1025	76				
			1027	78				
			1030	56				
			1032	56				
			1047	35				
			1050	22				Cigarette lit 10:57
			1057	24				out 11:04
			1103	24				
			1105	56				
			1107	69				
			1109	64				Cigarette lit 11:12
			1113	52				out 11:19
			1122	39				
			1124	62				Cigarette lit 11:26
			1131	50				out 11:30
			1134	97				lit 11:31
			1136	101				lit 11:33
			1143	115				out 11:37
			1145	147				out 11:40

(continued)

TABLE 94. (cont'd.)

Date	Location	Start Time	End Time	Concentration	Baseline Drift	HEPA Reading	Corrected Reading	Comments
			1200	88				Noticeable smoke pall about 4' high
		1648	1651		4			
		1651	1701	13			9	
3/26		1202	1212	68				Immediately following smoking episode; level at 12:04 was 80 μg/m^3
		1212	1215	22				
		1215	1217	20				
3/24	3rd-Floor Lounge	1709	1720	25				No smokers present
		1750	1752		3			Three smokers present--each had smoked 1 cig. in past 15 min.
		1752	1754	106			103	
		1754	1756	100			97	
		1756	1758	76			73	No smoking at time of measurement.
		1758	1800			3		
		1801	1826			5		Nine somkers present -- most of all had smoked in past hour.
		1835	1837	267			259	
		1837	1839	278			270	
		1839	1841	326			318	Two smoking during time of measurement.
		1841	1843	353			345	
		1843	1845	309			301	
		1845	1849			11		
3/25		1257	1300		3			Instrument #1
		1302	1318	16			12	
		1320	1333		0			
		1333	1339			6		

(continued)

TABLE 94. (cont'd.)

Date	Location	Start Time	End Time	Concentration	Baseline Drift	HEPA Reading	Corrected Reading	Comments
		1258	1300		0			Instrument #2
		1302	1318	23				
		1318	1332			11	12	
3/24	5th-Floor Lounge	1723	1727		0			
		1728	1747	13			13	
	Room 439	1859	1906	29			13	
		1906	1909			16		
	Room 101	1923	1931	20				
	Hallway outside boiler room	1936	1937					
		1937	1943	11				
	Dining Room	1946	1956	12				
3/25	5th-Floor Lounge	1348	1400	9			8	Instrument #1
		1400	1406			1		
		1348	1402	18				Instrument #2
	Outside (5th Floor)	1420	1428		28			Instrument #1 (not yet equilibrated to cold outdoor temp.)
		1428	1435		12			
		1435	1447		8			
		1448	1514	9				
		1515	1519		19			

(continued)

TABLE 94. (cont'd.)

Date	Location	Start Time	End Time	Concentration	Baseline Drift	HEPA Reading	Corrected Reading	Comments
3/26	3rd-Floor Lounge	1250	1252	22				1-2 Cigs. smoked between 1252 and 1310. Peak between 1310 and 1312 of about 130 μg/m^3.
		1252	1310	55				
			1315	100				
			1318	69				
			1320	58				
			1323	44				
			1326	33				
			1328	31				Cigarette lit 1330
			1331	23				2nd smoker enters room: 1330
			1334	58				2nd smoker leaves room 1331
			1336	44				Cigarette out 1334
			1338	58				Cigarette lit 1335
			1340	70				Cigarette out 1340
			1342	62				
			1344	83				
			1346	70				
			1349	64				
			1351	70				
			1354	65				Smoker enters room 1352, leaves room 1354
			1356	65				
			1358	58				
			1400	42				
			1402	55				
			1404	55				
			1407	61				

TABLE 94. (cont'd.)

Date	Location	Start Time	End Time	Concentration	Baseline Drift	HEPA Reading	Corrected Reading	Comments
		1420	1428		+5			
		1428	1435		-5			
		1435	1503	9				(probably not equilibrated)
		1504	1513			-6		
3/15	Administrator's Office	1118	1143	15			15	Instrument #1
		1143	1150		0		14	
		1158	1211	14				
		1122	1143	42				Instrument #2 (probably not equilibrated)
		1144	1150		6			
		1156	1211	27				
	Dining Room	1225	1229		-1			Instrument #1
		1229	1235	12				
		1237	1247		-1			
		1226	1229		0		5	Instrument #2
		1229	1236	17				
		1239	1248			12		
	3rd-Floor Lounge	1258	1300		-3		28	Instrument #1
		1302	1318	16				
		1326	1333		0			
		1333	1339			6		
		1258	1300		0		12	Instrument #2
		1302	1315	23				
		1324	1331			11		

(continued)

TABLE 94. (cont'd.)

Date	Location	Start Time	End Time	Concentration	Baseline Drift	HEPA Reading	Corrected Reading	Comments
			1409	44			42	
		1409	1501			2		
		1501	1520	28			26	Probably some smoking between 1501 and 1520
		1520	1522	31			29	

---

[a] $\mu g/m^3$

TABLE 95. RESPIRABLE PARTICULATES -- SMOKING AREAS

Date	Location	Total Time Measured[a]	Approximate Mean Concentration[b]	Range[b]	No. of Smokers Present	No. of Cigarettes Smoked
3/24	2nd Floor Lounge	60	60	24-100	1	3
		57	80	24-147	2	4
		13	9	9	0	0
3/26		15	50	20-68	1	0
3/24	3rd Floor Lounge	11	25[c]	25	1	0
		10	90	73-103	3	0
		49	300	259-345	9	>2
3/25		42	12	12	0	0
3/26		152	60	22-100	1-2	>4
3/24	Room 101	8	20[c]	20	1	0

[a] Minutes.

[b] $\mu g/m^3$.

[c] Uncorrected reading.

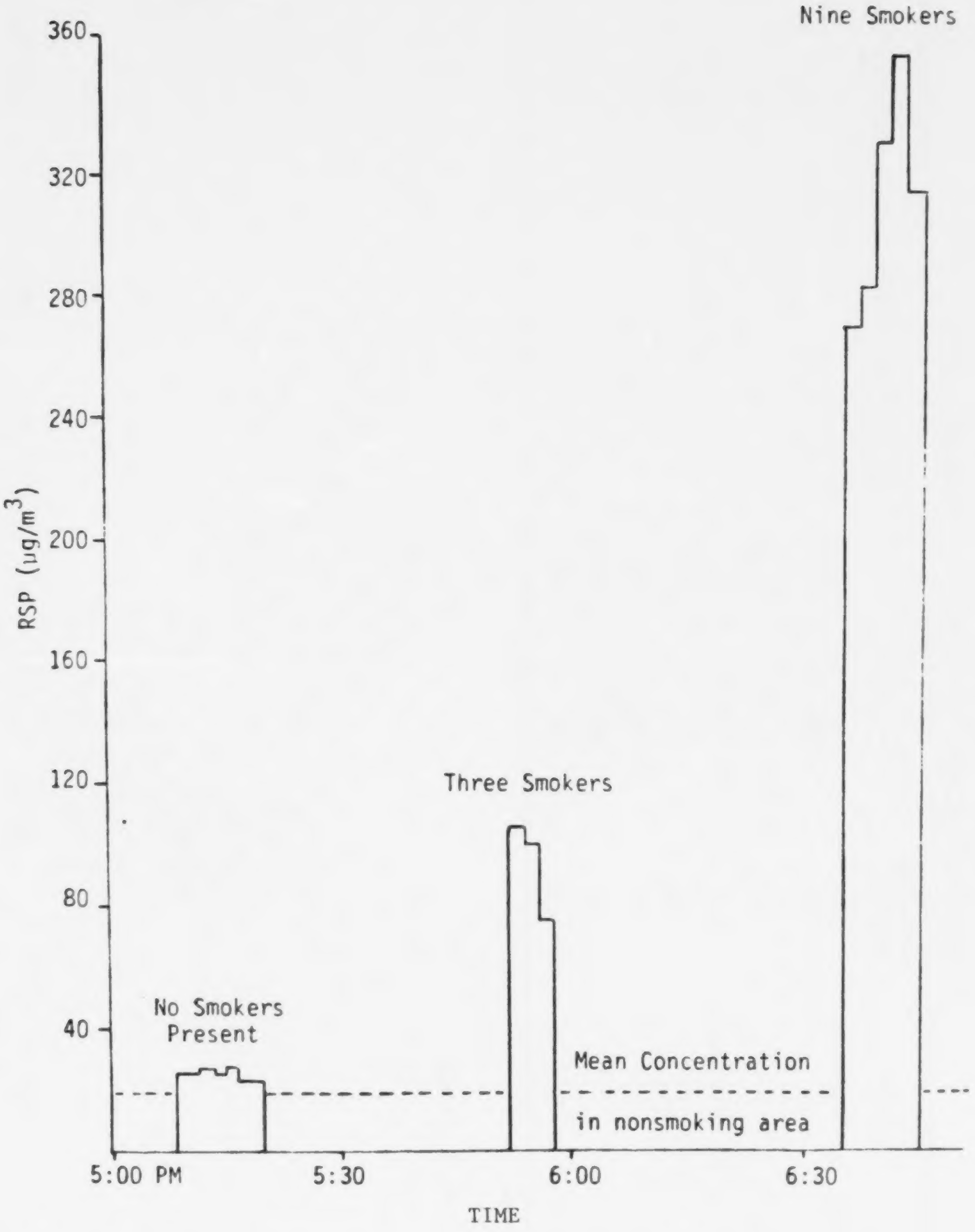


Figure 36. Respirable particulates in 3rd floor lounge of the elderly home-1 (3/24/83).

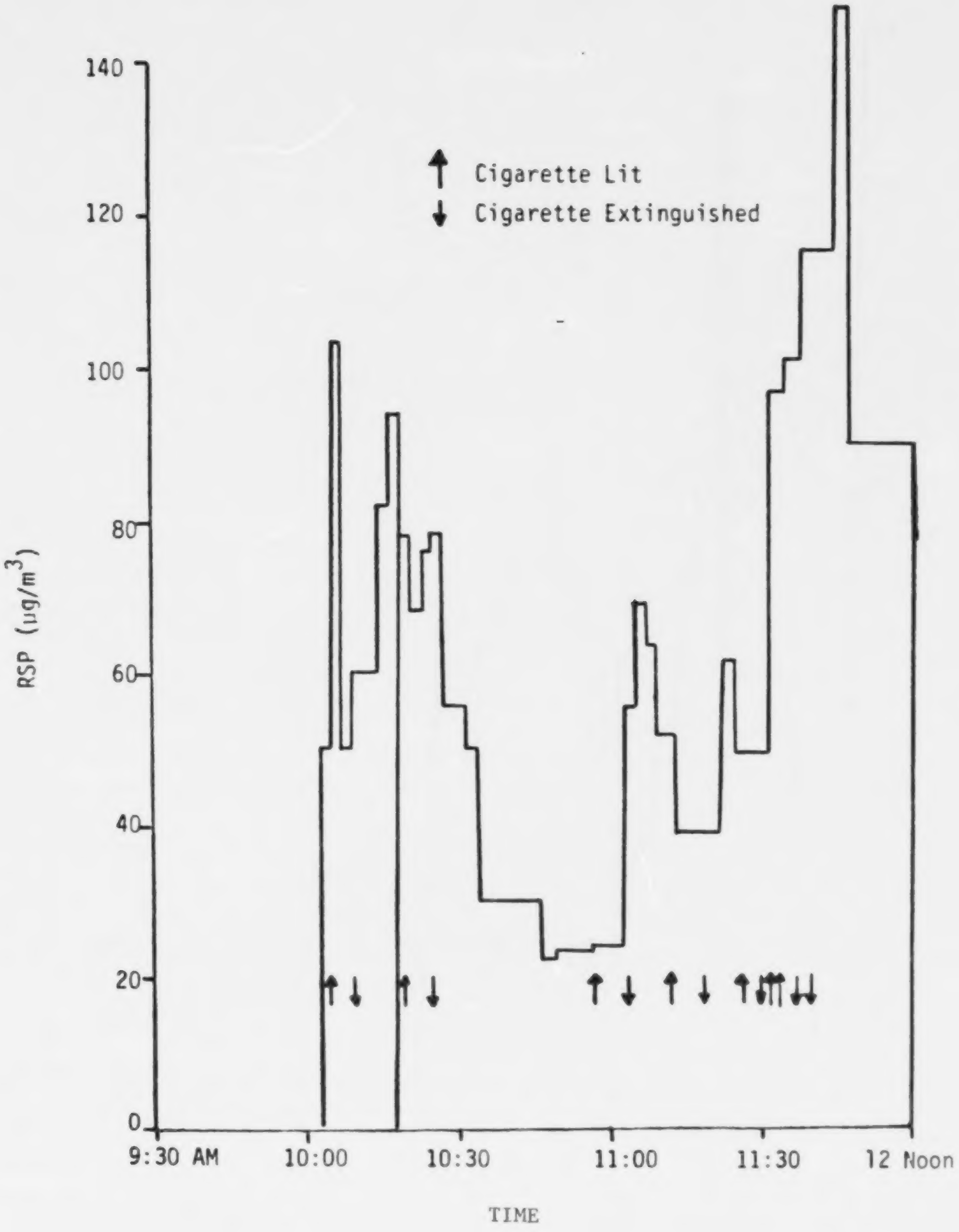


Figure 37. Respirable particulates in 2nd floor lounge of the elderly home-1 (3/24/83).

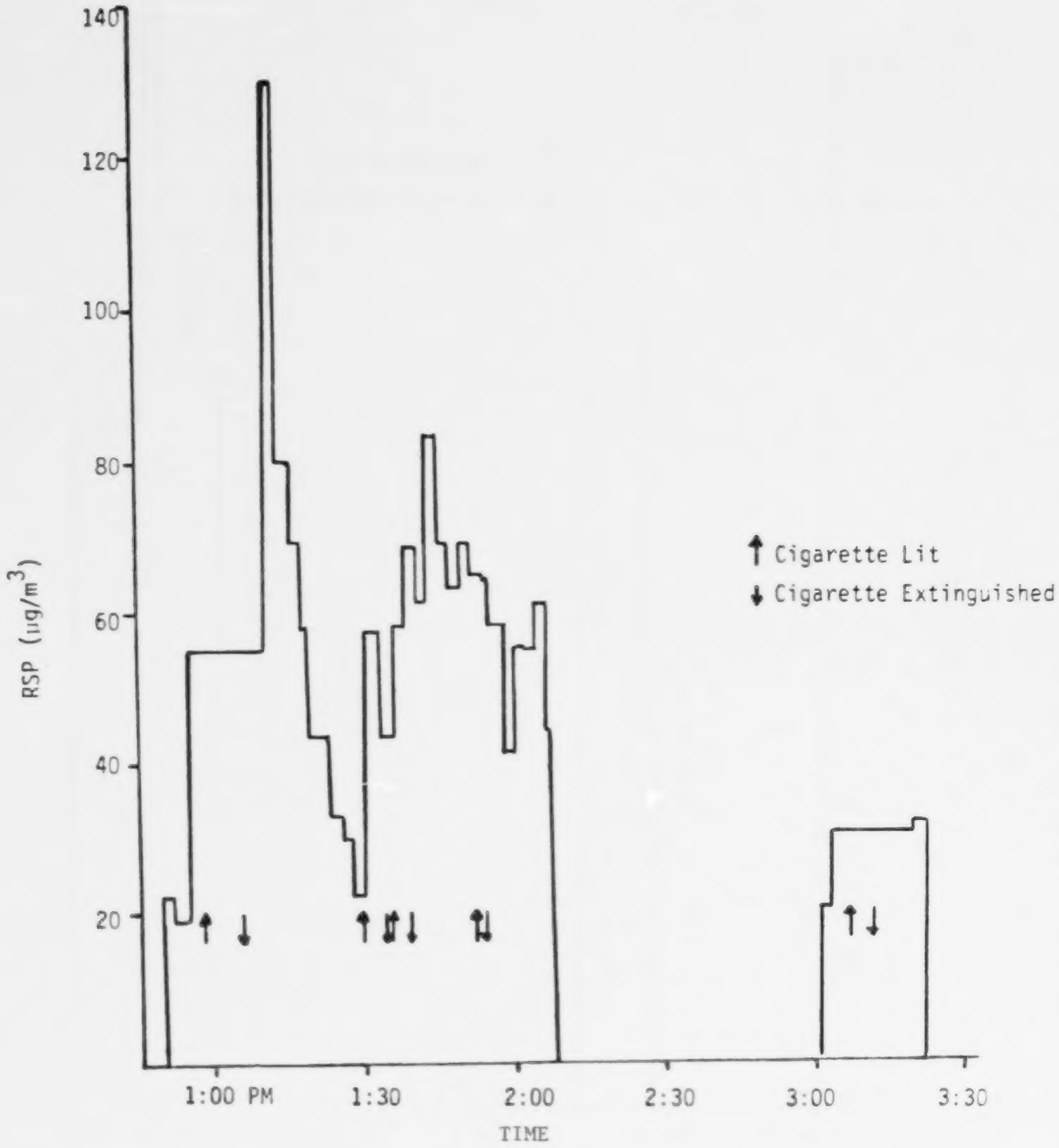


Figure 38. Respirable particulates in 3rd floor lounge of the elderly home-1 (3/26/83).

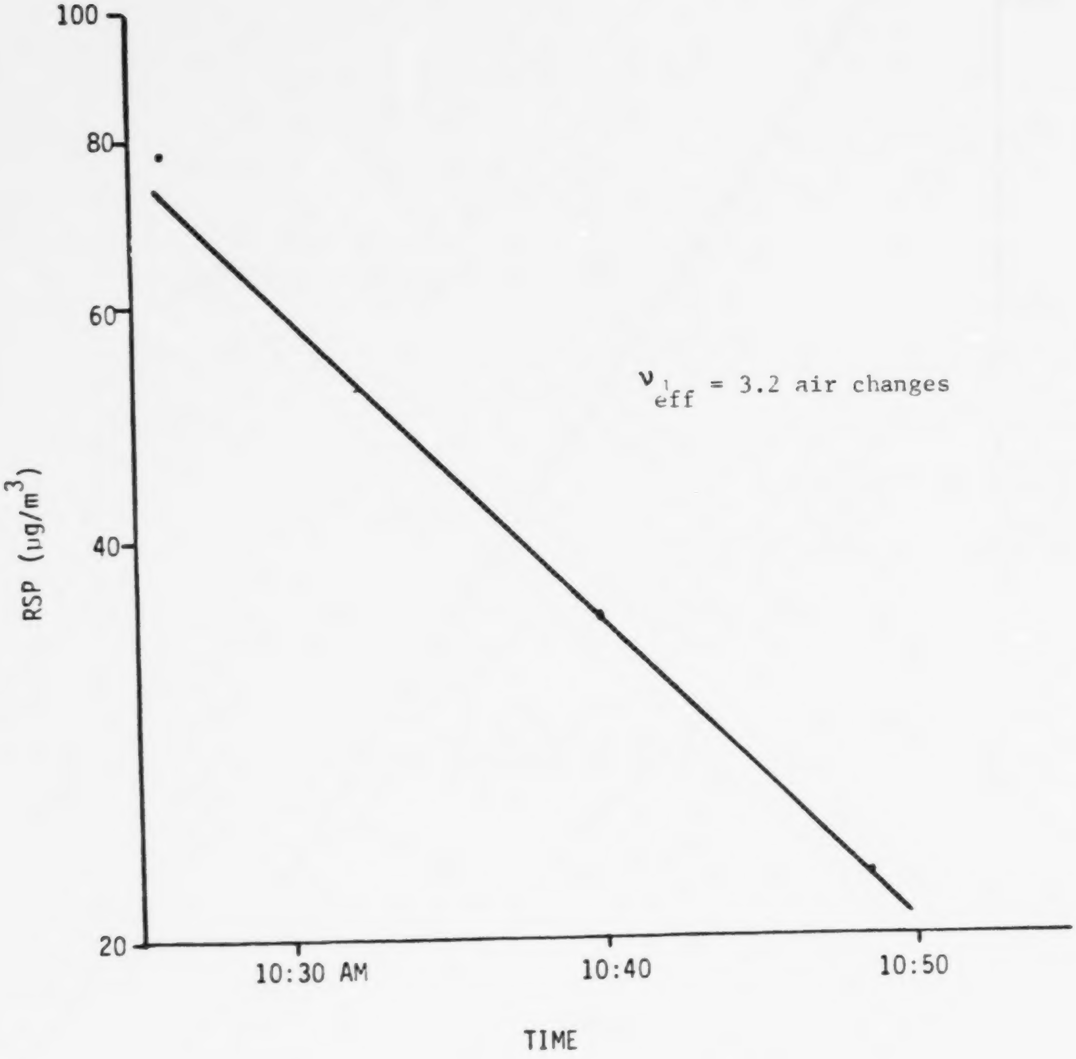


Figure 39. Decline of respirable particulates following smoking - 3rd floor lounge of the elderly home-1 (3/24/83).

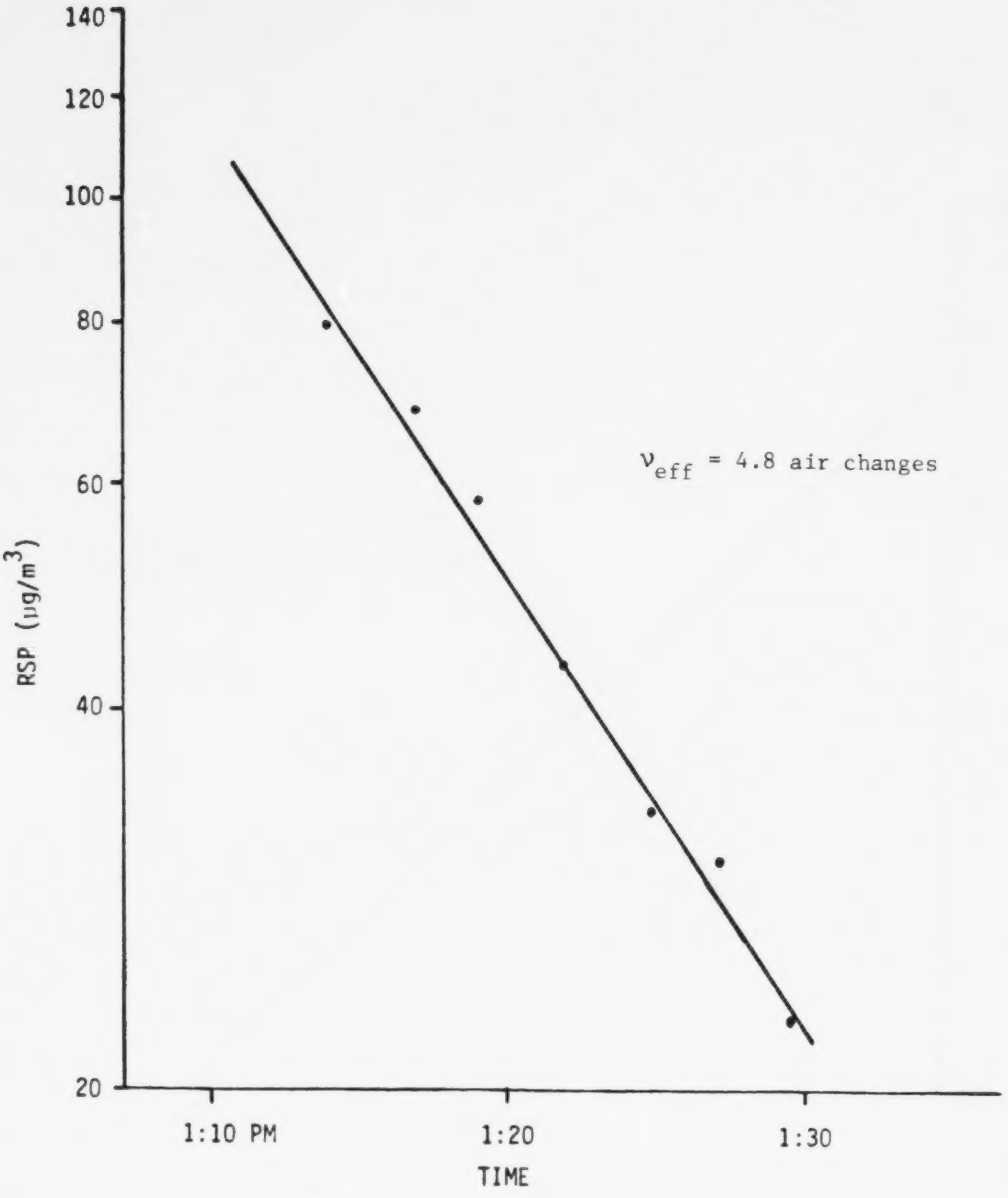


Figure 40. Decline of respirable particulates following smoking - 3rd floor lounge of the elderly home-1 (3/26/83).

The rate of emission of respirable particulates can be calculated from each cigarette by using a simple one-compartment model with an unknown source term, S (μg/min), the measured respirable particulate concentrations and air exchange rates. The concentration above background at time t(C(t)) is a function of the initial concentrations, C_0, the volume, V, and the characteristic particle removal time, τ, (τ is a function both of the actual air exchange rate and other particle removal processes -- settling, plate-out, etc).:

$$C(t) = C_0 e^{-t/\tau} + \frac{S\tau}{V} (1-e^{-t/\tau})$$

This equation assumes perfect, instantaneous mixing. In fact, observed concentrations in both smoking lounges continued to rise for periods of two to eight minutes after the cigarettes were extinguished (see Figures 37 and 38). An estimate of S can be obtained by assuming that these maximum values, reached two to eight minutes after smoking stopped, would have been reached at the time smoking stopped with perfect, instantaneous mixing. (In fact, this is a conservative estimate of S since particles were continually being removed during the two to eight minute period of mixing; thus the observed maximum would have been less than the theoretical maximum). An example of a calculation is given below. It was first assumed that the background concentration is 15 $\mu g/m^3$ (based on the results of monitoring the nonsmoking area, which ranged from 10-20 $\mu g/m^3$). On March 26, the effective air exchange rate was 4.8 ach, corresponding to a particle removal time of 12.5 minutes (t =60 min/τ). The volume of the 3rd floor lounge (18' x 27' x 8') is 110 m^3. At time t = 0, C_0 = 40 $\mu g/m^3$ (the measured value of 55 less the background of 15).

At t = 5, C(5) = 85 $\mu g/m^3$. Thus:

$$C(5) = C_0 e^{-t/\tau} + \frac{S\tau\ (1-e^{-t/\tau})}{V}$$

$$85 = 40\ e^{-5/12.5} + (.1136)\ (1-e^{-5/12.5})\ S$$

$$S = (85-27)/.0374$$

$$S = 1550\ \mu g/min$$

Similar calculations for three other cases of cigarette smoking gave values of S of 880, 2341, and 358 µg/min. Multiplying each value by the number of minutes smoked gives values of the mass of particulates released per cigarette of 6,400 µg; 4,000 µg; 11,700 µg; and 2,500 µg.

This average value of ~6,000 µg/cigarette may be compared with the value of ~11,000 µg/cigarette obtained from a single measurement by Girman et al.(8-4).

We may also compare our measurements to an equation developed by Repace and Lowrey relating tobacco smoke concentrations to occupancy density:

$$C = 25.6\ P_a/\nu\ \mu g/m^3$$

Here P_a is occupany in persons per 1,000 ft^2 and ν is the air exchange rate in ach. The equation was developed assuming 1/3 of the occupants are smokers who smoke two cigarettes an hour. For this example, it is assumed that all the persons in the smoking lounge were smokers, and that a background level of 15 $\mu g/m^3$ would be obtained in the absence of smoking. Under these conditions, the average concentrations of tobacco smoke in the 3rd floor smoking lounge on March 24, (Figure 36) were 10, 78, and 284 $\mu g/m^3$ for the case of 0, 3, and 9 smokers. Repace's equation predicts 0, 99, and 296 $\mu g/m^3$, respectively.

School--

Duplicate measurements by two Piezobalances showed general agreement to within ±20% for measurements with and without the HEPA filter (Table 96). However, one instrument read consistently higher than the other when the HEPA filter was attached and consistently lower when it was not attached. Since the concentration estimates were obtained from a relatively small number produced by subtracting two relatively large numbers, the results showed a large percentage difference and a consistent bias of about 8±2 $\mu g/m^3$.

This bias between the two Piezobalances is small but consistent. As with analyses performed at the elderly home, the low RSP levels encountered in the school led to large apparent percentage differences in the estimated concentrations. The reason for the bias is not known. Both instruments were factory calibrated, instrument #2 having been calibrated more

TABLE 96. SIDE-BY-SIDE READINGS OF TWO PIEZOBALANCE INSTRUMENTS IN THE SCHOOL

	(Hz/2 min)		
	Instrument Reading[a]		Ratio $\frac{\#1}{(\#1 + \#2)/2}$
	#1	#2	
With filter	10.6	9.6	1.05
	6.9	7.1	0.99
	5.0	5.6	0.94
	4.0	6.8	0.74
	4.4	5.2	0.92
Without filter	12.1	9.6	1.12
	10.8	7.0	1.21
	8.8	6.2	1.17
	12.6	13	0.98
	7.3	5.1	1.18
Estimated concentration (µg/m^3)			Bias (#1-#2) (µg/m^3)
	4.4	0	+4.4
	11	0	+11
	11	0	+9
	24	17	+7
	7.5	0	+7.5
Average bias			7.8 ± 2.4

[a] Concentration in µg/m^3.

recently. Instrument #1 showed a slower rise to the proper precipitation current and, in fact, was always somewhat below the optimum level. However, the extremely low readings shown by instrument #2 appear less credible than those of instrument #1.

On an absolute scale, the two instruments both indicate very low particulate levels (generally less than 12 $\mu g/m^3$) at three indoor locations on both days (Tables 97 and 98). A fourth location, the gymnasium, appeared to have significantly higher respirable particulate levels: about 20 $\mu g/m^3$. The very low readings agree with both theory and observation, since the school is all-electric and less than 10 years old, the number of pupils is rather small (~250 pupils in 1.3 million cubic feet), and smoking is not allowed (and was never observed over 2 days except in the teachers' lounge). Outdoor levels were also low, an expected finding since several days of heavy rain had been followed by a clear high-pressure front just before sampling began.

Comparisons with the March sampling at the elderly home-1 show similar concentrations in the nonsmoking areas of less than 20 $\mu g/m^3$. However, concentrations in those areas with active smoking ranged from 80-350 $\mu g/m^3$. It is interesting to note that the bias observed between the two instruments at the elderly home-1 was reversed at the school. The main difference in the two sampling environments was an extremely low relative humidity of 12-18% at the elderly home-1 compared to a more normal value of 30-40% at the school. It may be that one crystal is more affected by humidity changes than the other.

Collected Filter Samples

Measured inhalable and respirable particulate concentrations for samples collected during this program using the dichotomous and NBS samplers are given in Tables 99 through 101. Although only a limited amount of data is available, some observations can be made.

At the office building, most levels of inhalable and respirable particulates were low with a decrease in levels occurring from the first to the third trip. During the first trip, particulate levels were higher on the first day than on the second day for both indoor and outdoor samples. This could be a result of moving activities since during this period furniture and office equipment was being transported into the building.

TABLE 97. RESPIRABLE PARTICULATE MEASUREMENTS AT THE SCHOOL
May 23, 1983

	Minutes Sampled	Change in Frequency (Hz)	Frequency/Δt (Hz/2 min)	Corrected Reading (μg/m^3)
1st Floor				
No Filter	16	89	11	18
Filter	13	29	45	
2nd Floor				
No Filter	8	37	9	14
Filter	8	17	4	
3rd Floor				
No Filter	12	44	7	8
Filter	8	18	4.5	
Rooftop				
No Filter	17	140	16	28
Filter	6	18	6	

TABLE 98. RESPIRABLE PARTICULATE MEASUREMENTS AT THE SCHOOL - MAY 24, 1983

	Sampling Time (min)		Frequency Change (Hz)		Frequency Change/Time Change (Hz/2 min)		Corrected Reading ($\mu g/m^3$)
	Filter	No Filter	Filter	None	Filter	No Filter	
1st floor							
Inst. #1	10.0	12.0	53	73	10.6	12.2	4.4
Inst. #2	10.0	10.0	48	48	9.6	9.6	0
2nd floor							
#1	11.0	10.0	38	54	6.9	10.8	11
#2	11.0	10.0	39	35	7.1	7.0	0
3rd floor							
#1	10.0	10.0	25	44	5.0	8.8	11
#2	10.0	10.0	28	31	5.6	6.2	2
Gymnasium							
#1	10.0	10.0	20	63	4.0	12.6	24
#2	10.0	10.0	34	65	6.8	13.	17
Rooftop							
#1	10.0	20.0	22	73	4.4	7.3	7.5
#2	10.0	20.0	26	51	5.2	5.1	0

TABLE 99. INHALABLE AND RESPIRABLE PARTICULATE LEVELS MEASURED AT THE OFFICE BUILDING

		Concentration (μg/m^3)			
		Trip 1		Trip 3	
Sample	Description	Inhalable	Respirable	Inhalable	Respirable
Location 1	First floor office				
Day 1		16	23	ND[a]	15
Day 2		6.9	10	74	20
Location 2	First floor secretarial area				
Day 1		NS[b]	NS	NC[c]	NC
Day 2		NS	NS	16	58
Location 3	Second floor office				
Day 1		18	27	ND	ND
Day 2		71	12	ND	
Location 4	Second floor secretarial area				
Day 1		NS	NS	NS	NS
Day 2		NS	NS	NS	NS
Location 5	Third floor copier room				
Day 1		NS	NS	NS	NS
Day 2		NS	NS	NS	NS
Location 6	Outside				
Day 1		14, 14[d]	21, 22[d]	ND	6.9
Day 2		13	15	15	14

[a] Not detected.

[b] Not scheduled for collection.

[c] Not collected; pump failure.

[d] Duplicate measurements.

TABLE 100. INHALABLE AND RESPIRABLE PARTICULATE LEVELS MEASURED AT THE ELDERLY HOME-1

Sample	Description	Concentration (μg/m^3)	
		Inhalable	Respirable
Location 1	Outside		
Day 1		8.1	12
Day 2		9.3	9.0
Day 3		7.1	10
Location 2	5th Floor Lounge-nonsmoking		
Day 1		5.5	8.2
Day 2		5.7	6.1
Day 3		4.6	6.3
Location 3	3rd Floor Lounge-smoking		
Day 1		8.2, 8.7[a]	26, 29[a]
Day 2		NM[b]	30
Day 3		8.7	31
Location 4	Dining Room		
Day 1		1.5	11
Day 2		1.3	7.3
Day 3		.99, 2.3[a]	8.2, 4.0[a]
Location 5	Apartment-nonsmoker		
Day 1		7.3	11
Day 2		6.4	9.0
Day 3		7.5	7.7
Location 6	Apartment-nonsmoker		
Day 1		10	34
Day 2		9.9	NM[c]
Day 3		12	44

[a] Duplicate measurements.

[b] Not measured.

[c] Not measured; hole in filter.

TABLE 101. INHALABLE AND RESPIRABLE PARTICULATE LEVELS MEASURED AT ELDERLY HOME-2

Sample	Description	Concentration ($\mu g/m^3$) Inhalable	Concentration ($\mu g/m^3$) Respirable
Location 1	First floor commons area		
Day 1		7.5	19
Day 2		4.9	13
Day 3		7.0	16
Location 2	Apartment-nonsmoker		
Day 1		5.6	9.5
Day 2		5.7	7.7
Day 3		NM[a]	NM[a]
Location 3	Apartment-unoccupied		
Day 1		16	9.7
Day 2		6.4	10
Day 3		32	22
Location 4	Apartment-smoker		
Day 1		14	100
Day 2		6.3	75
Day 3		8.6, 8.2	100, 85
Location 5	Outside		
Day 1		NC[b]	NC[b]
Day 2		8.2	3.6
Day 3		NC[b]	NC[b]

---

[a] Not measured - sample lost during shipping.

[b] Not collected - pump failure.

Low respirable particulate levels are consistent with the absence of smokers at any of the sampling locations.

On the other hand, data are elevated for smoking areas at both of the elderly homes. For both of the sites, slightly elevated concentrations compared to nonsmoking areas are seen for the inhalable particulate. However, very large increases are seen for the respirable particulate samples, with the highest levels (~100 $\mu g/m^3$) observed in the smoker's apartment at the elderly home-2. Results obtained from the dichotomous samplers are in good agreement with the Piezobalance measurements for the 5th floor lounge and the dining room at the elderly home-1. Since there was no smoking in these areas, it is not surprising that integrated and real time measurement agree well. For the smokers lounge, however, the real time measurements show higher readings than the integrated measurements, as expected since the integrated measurements included times when no smokers were present. Comparison between the two are difficult unless accurate information is available on the number of cigarettes smoked throughout the day.

At the elderly home-1, indoor concentrations of inhalable and respirable particulates were either equal to or below outdoor levels. Lowest concentrations were detected in the dining room which was ventilated by a separate air handling system. For the elderly home-2, inhalable particulate concentrations were generally the same for indoor and outdoor samples. However, for the respirable particulates in locations without smoking, indoor concentrations were higher than the outdoor concentrations.

PESTICIDES/PCBs

Several types of statistical analyses were performed on the data for pesticides/PCBs collected during the indoor air study. For the initial analysis, the percentage of air samples with measurable concentrations (% above the quantifiable limit) of target pesticides/PCBs was calculated for each field monitoring trip. Then summary statistics including mean, median, and maximum concentrations were calculated for all targets which were measurable in greater than 25% of the samples. Finally, in a few selected cases correlations with sample concentrations were tested using a t-test. Caution should be exercised in interpreting data presented for the pesticides and PCBs. Significant problems occurred during the analysis of field samples using packed column GC/ECD. Many of the field samples contained high levels of air contaminants which interfered with the analysis of the targets pesticides/PCBs. This led to a number of samples which could not be quantitated. Furthermore, when the background contaminants resulting from other organics in air samples were high, identification for quantitation became subjective and may have led to significant errors. Because of these problems, data for the pesticides/PCBs have not been included in the main part of this report, rather they are presented in Appendix F.

ELEMENTS

This section describes the statistical analysis of the elemental data. Data are available on 29 elements with the following exceptions. Zirconium and molybdenum data are absent from the school and first two trips to the to the office building and the elderly home-2; and rubidium, strontium, zirconium, molybdenum, cadmium, and mercury are absent from the elderly home-1. For the other 23 elements, data are complete.

At the office building and the elderly home-2, a single sample was collected over a 24 hour period from each location within or outside the building. Samples were collected on air particulate aerosol grade filters with a lower particle size limit of 0.3 μm. Sampling was performed on two consecutive days (6 monitoring locations) during each of the three trips to the office building and on three consecutive days (5 monitoring locations) during the one trip to the elderly home-2. Duplicate samples were collected at the second floor secretarial area on the first day of each trip to the office building and outdoor on the second day of the second trip to the office building. One duplicate was obtained at the elderly home-2. In all, there were 12 samples collected during each trip to the office building and 16 collected during the trip to the elderly home-2. Statistical analysis on this small quantity of data was, of necessity, quite limited.

The "streaker" filters used for sample collection at the school and elderly home-1 were of two types, fine (0.25 mm) and coarse (> 2.5 mm) particulate filters. Thus, the particulate sample collected on the 24 hour filters (> 3.0 mm) is roughly equivalent to that collected on the "streaker" coarse filter. In most cases, there was a 72-hour sample collection on one filter of each type for each of the six home and four school monitoring locations. In addition, there were duplicate samples collected for 48 hours on the roof of the elderly home-1, for 24 hours from the first floor (smoker's) room, and for the full 72 hours on the second floor of the school. Each of the filters - 5 fine and 5 coarse from the school, 7 fine and 8 coarse from the elderly home-1 - provided a number of separate data points. Measurements were made from 4-hour segments of the filters exposed at the school and 1-hour segments of filters exposed at the elderly home-1. Considered as discrete observations, these filter segments, therefore, yielded a sizable sample: 168 for the school and 867 for the elderly home-1. It was also possible to compare locations using the entire 72-hour histories of concentrations and to examine relationships between concentration and time of day.

Most of the data from PIXE analysis were reported as actual numbers (μg/filter segment), with "not detected" only if the value was below the instrument's limit of detection. However, the method limits of detection (LOD) and quantifiable limits (QL) were derived from the mass of the elements on "blank" filters (Section 6). These method detection limits were used in computing summary statistics and percentages detected, one half of the LOD value replaced the reported value if that value was below the LOD and 5/8 the QL used if the value was above the LOD but below the QL. Where a duplicate sample was available, it was averaged with the other sample, and an element was considered detected if either sample was above the QL. In the following sections, percent detected (above the QL) and summary statistics are presented for the various buildings and metals. In general, the principal comparison of interest is between indoor versus outdoor monitoring locations.

A detailed description of sampling locations is given in Sections 4 and 5.

Tables 102 and 103 list percentages of indoor and outdoor air samples with measurable concentrations for each building, trip, and element. Because of the small number of observations available from the office building and the elderly home-2, no firm conclusions may be drawn for these buildings, particularly in comparing indoor with outdoor air samples. But it does not appear that percent measurable decreased over time at the

TABLE 102. PERCENT MEASURABLE - ELEMENTS BY BUILDING: 24-HOUR FILTERS

	Percent Measurable							
	Office Building							
	Trip 1		Trip 2		Trip 3		Elderly Home-2	
Elements	Indoor (9)[a]	Outdoor (2)	Indoor (8)	Outdoor (2)	Indoor (9)	Outdoor (2)	Indoor (12)	Outdoor (3)
Sodium	0	50	0	0	0	0	0	0
Magnesium	0	0	0	0	0	0	0	0
Aluminum	0	0	0	0	0	0	0	0
Silicon	78	100	0	100	0	0	8	0
Phosphorus	0	0	0	0	0	0	0	0
Sulfur	33	100	0	50	22	100	25	0
Chlorine	0	0	0	0	0	0	0	0
Potassium	89	100	25	50	22	100	42	33
Calcium	100	100	63	100	56	50	50	33
Scandium	0	0	0	0	---[b]	---	---	---
Titanium	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0
Manganese	0	0	0	0	0	0	0	0
Iron	22	100	13	50	11	0	25	0
Cobalt	0	0	0	0	---	---	---	---
Nickel	0	0	0	0	0	0	0	0
Copper	33	100	0	0	0	0	0	0
Zinc	22	0	0	0	0	0	0	0
Arsenic	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	0	0	0	0
Bromine	0	0	0	0	0	0	0	0
Rubidium	0	0	0	0	0	0	0	0
Strontium	0	0	0	0	0	0	0	0
Zirconium	---	---	---	---	0	0	0	0
Molybdenum	---	---	---	---	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0
Mercury	0	0	0	0	0	0	0	0
Lead	0	0	0	0	0	0	25	0

---

[a] Sample size.

[b] No data.

TABLE 103. PERCENT MEASURABLE - ELEMENTS BY BUILDING: "STREAKER" FILTERS

	Percent Measurable							
	School[a]				Elderly Home-1			
	Fine		Coarse		Fine		Coarse	
Elements	Indoor (54)[b]	Outdoor (12)	Indoor (54)	Outdoor (12)	Indoor (264)	Outdoor (72)	Indoor (312)	Outdoor (72)
Sodium	0	0	0	0	0	0	0	0
Magnesium	0	0	0	0	0	0	0	0
Aluminum	0	0	0	0	0	0	0	0
Silicon	61.1	100	9.3	0	0	0	0	36.1
Phosphorus	0	0	0	0	0	0	0	0
Sulfur	22.2	0	81.5	100	0	0	52.2	97.2
Chlorine	0	0	0	0	0	0	0.3	0
Potassium	0	0	63.0	75.0	0	0	17.6	0
Calcium	50.0	50.0	37.0	16.7	0.4	0	0.3	25.0
Scandium	0	0	0	0	0	0	0	0
Titanium	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	0	0	0	0
Manganese	1.9	0	0	0	0	0	0	0
Iron	74.1	100	33.3	100	2.7	5.6	0	4.2
Cobalt	0	0	0	0	0	1.4	0	0
Nickel	0	0	0	0	0.4	0	0	0
Copper	1.9	0	1.9	8.3	0	0	0	0
Zinc	74.1	91.7	87.0	100	0	0	5.1	33.3
Arsenic	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	0	0	0	0
Bromine	0	0	9.3	41.7	0	0	0	0
Rubidium	0	0	0	0	---	---	---	---
Strontium	0	0	0	0	---	---	---	---

(continued)

TABLE 103 (cont'd.)

Elements	Percent Measurable							
	School[a]				Elderly Home-1			
	Fine		Coarse		Fine		Coarse	
	Indoor (54)[a]	Outdoor (12)	Indoor (54)	Outdoor (12)	Indoor (264)	Outdoor (72)	Indoor (312)	Outdoor (72)
Zirconium	---[c]	---	---	---	---	---	---	---
Molybdenum	---	---	---	---	---	---	---	---
Cadmium	0	0	0	0	---	---	---	---
Mercury	0	0	0	0	---	---	---	---
Lead	0	8.3	61.1	100	0	0	0	12.5

[a] School: 1 sample/4 hours.
Elderly Home-1: 1 sample/hour

[b] Sample size.

[c] No data.

office building, at least for silicon, iron, copper, and zinc. The other elements with more than one quantifiable detection at the office building were sulfur, potassium, and calcium. There were only a few quantifiable values from the elderly home-2; one or two each, at indoor locations, for silicon, sulfur, iron, zinc, and lead. Several indoor and outdoor samples had measurable concentrations of potassium and calcium.

Table 103 treats each 1-or 4-hour filter segment as a separate observation from the elderly home-1 or the school, and provides a comparison of the two kinds of filters. The elements detected with high frequency at the school were silicon on the fine particulate filters, sulfur, potassium, bromine, and lead on the coarse particulate filters, and calcium, iron, and zinc by both filter types. Silicon, iron, bromine, and lead were measurable more frequently outdoors than indoors. None of the elements appear to be more prevalent indoor. Very few elements were detected at the elderly home-1. Iron was the only element with more than 20% measurable on the fine particulate filters. Percentage measurable of over 10% on the coarse particulate filters were found for silicon, calcium, zinc, and lead outdoors, for potassium indoors, and for sulfur both indoors and outdoors. Sulfur was the only element measurable on more than 50% of the samples.

In Table 104 the percent of measurable concentrations on streaker filters for selected elements are broken down further by time period. The elements chosen because of frequency of detection and intrinsic interest are silicon, calcium, iron, bromine, and lead. "Daytime" in the case of the school refers to the two 4-hour periods roughly corresponding to the school day; in the case of the elderly home-1, it refers to approximately 10 a.m. to 6 p.m. The periodicity of the data will be examined in more detail later in this section, but even these simple tabulations show that the concentrations of silicon, calcium, and iron were measurable inside the school more frequently during the school day than at night. Percent measurable for calcium in outdoors air samples was also more frequent during the day. For lead and indoor bromine there are no apparent day/night differences, but outdoor bromine was detected only during the "overnight" period. There are no substantial day/night phenomena in the data from the elderly home-1.

TABLE 104. PERCENT OF FILTER SEGMENTS WITH MEASURABLE CONCENTRATIONS OF ELEMENTS BY BUILDING, INDOORS/OUTDOORS, TIME PERIOD, AND METHOD: "STREAKER" FILTERS

		School				Elderly Home-1			
		Indoor		Outdoor		Indoor		Outdoor	
Filter Type	Element	Overnight	Daytime	Overnight	Daytime	Overnight	Daytime	Overnight	Daytime
Fine Particulate	Si	41.7	100	100	100	1.2	0	0	0
	Ca	38.9	72.2	37.5	75	0.6	0	0	0
	Fe	61.1	100	100	100	2.4	3.2	6.3	4.2
	Br	0	0	0	0	0	0	0	0
	Pb	0	0	12.5	0	0	0	0	0
	Sample Size[a]	36	18	8	4	170	94	48	24
Coarse Particulate	Si	0	27.8	0	0	0	0	37.5	33.3
	Ca	22.2	66.7	12.5	25	0	0.9	18.8	37.5
	Fe	16.7	66.7	100	100	0	0	4.2	4.2
	Br	8.3	11.1	62.5	0	0	0	0	0
	Pb	61.1	61.1	100	100	0	0	14.6	8.3
	Sample Size[a]	36	18	8	4	206	106	48	24

[a] School: 1 sample/4 hours
Elderly Home-1: 1 sample/hour

Summary statistics on concentration levels for the office building and the elderly home-2 are provided in Table 105. The mean, median, and maximum concentrations, and median QLs are listed for each building and trip, both indoors and outdoors, for the four elements which were detected and considered of interest: silicon, calcium, iron, and lead. The median QL was obtained by dividing the LOD (one value for all 24-hour filters) for that metal by the volume for each sample, multiplying by four, and computing the median value.

The small sample sizes limit the usefulness of these statistics, but a few observations can be made. Silicon levels decreased sharply over the three trips to the office building. Indoor levels dropped between the first and second trips; outdoor levels were high until the third trip. High calcium concentrations were primarily found at indoor locations during the first trip. As will be seen when examining the actual data in Table 106, the large differences in statistics for iron are accounted for by a few outliers. It does appear that iron concentrations were higher indoors than outdoors at the elderly home-2. The same appears true for lead concentrations. Apart from lead in indoor air samples, concentrations were in about the same range in the two buildings.

Table 107 gives a finer breakdown for these buildings, showing average concentrations for the 1-4 observations at each sampling location. The trends noted above for silicon and calcium in the office building seem to apply to all indoor locations, with none of the five locations standing out as unusual. At the elderly home-2, the unoccupied room on the fifth floor had somewhat higher concentrations overall, and the common area on the first floor rather low values. One should note that for all these elements, each indoor and outdoor monitoring location at the home had at least one value below the quantifiable limit.

The actual individual observations for the office building (silicon, calcium, and iron) and the elderly home-2 (silicon, calcium, iron, and lead) can be found in Table 106. The values are listed as reported, with those below LOD or QL so noted. Here one can see the source of the inflated iron statistics for the office building, trip 2: a single concentration of 5900 ng/m^3 in the copier room. Unfortunately, only one sample was obtained for that room and trip, so there is no corroboration.

TABLE 105. SUMMARY STATISTICS FOR CONCENTRATIONS OF ELEMENTS BY SITE, INDOOR/OUTDOOR: 24-HOUR FILTERS

		Concentration (ng/m^3)							
		Office						Elderly Home-2	
		Trip 1		Trip 2		Trip 3			
Element	Statistic[a]	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
Si	Mean	1200	1500	630[b]	1700	350[b]	410[b]	410	300[b]
	Median	1000	1500	580	1700	500	410	490	120
	Std. Dev.	560	170	110	280	240	27	260	310
	Max.	2100	1600	780	1900	610	430	770	660
	Median QL[c]	910	620	910	910	800	650	980	980
Ca	Mean	1400	280	190	270	180	170	200	150
	Median	1100	280	170	270	150	170	150	20
	Std. Dev.	640	1	110	140	140	140	130	220
	Max.	2400	290	330	380	420	270	460	400
	Median QL	150	100	150	150	130	110	160	160
Fe	Mean	290	350	840	340	170	180[b]	490	52[b]
	Median	250	350	59	340	220	180	270	53
	Std. Dev.	110	15	2000	130	140	12	560	5
	Max.	490	360	5900	430	440	190	1900	57
	Median QL	400	270	400	400	350	280	430	430

(continued)

TABLE 105. (cont'd.)

		Concentration (ng/m^3)							
		Office							
		Trip 1		Trip 2		Trip 3		Elderly Home-2	
Element	Statistic[a]	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
Pb	Mean	39[b]	110	34[b]	100[b]	86	110	150	33[b]
	Median	31	110	31	100	79	110	140	33
	Std. Dev.	28	7	6	100	58	7	120	3
	Max.	110	110	42	170	160	117	400	36
	Median QL	250	170	250	250	220	180	270	270
	Sample Size	9	2	8	2	9	2	12	3

[a] If value below LOD, 1/2 LOD used in calculations instead of reported value. If value above LOD but below QL, 5/8 of QL used.

[b] All values below quantifiable limit.

[c] Median of the quantifiable limits for all observations.

TABLE 106. LISTING OF CONCENTRATIONS OF SELECTED ELEMENTS: OFFICE, TRIPS 1,2,3 AND ELDERLY HOME-2

Trip	Location	Day	Field (F)/ Duplicate (D)	Concentration[a] (ng/m^3)		
				Si	Ca	Fe
Office						
1	1	1	F	1300	1800	450(T)
	1	2	F	940	1100	330(T)
	2	1	F	2000	2400	490
	2	2	F	680(T)	580	210(T)
	3	1	F	1000	870	200(T)
	3	2	F	950(T)	1100	210(T)
	4	1	F	1800	1700	360
	4	1	D	2400	2800	580
	4	2	F	880	1000	210(T)
	5	1	F	1100	1500	260(T)
	6	1	F	1400	280	330
	6	2	F	1600	290	360
2	1	1	F	570(T)	280	170(T)
	1	2	F	790(T)	330	150(T)
	2	2	F	360(T)	160(T)	90(ND)
	3	1	F	420(T)	200	35(ND)
	3	2	F	260(T)	47(T)	39(ND)
	4	1	F	430(T)	28(ND)	48(ND)
	4	1	D	300(T)	250	36(ND)
	4	2	F	230(T)	34(ND)	35(ND)
	5	2	F	1000(T)	310	5900
	6	1	F	1500	170	210(T)
	6	2	F	1800	360	400(T)
	6	2	D	2100	390	540
3	1	2	F	420(T)	360	160(T)
	2	1	F	260(T)	150	81(ND)
	2	2	F	680(T)	0(ND)	54(ND)
	3	1	F	120(ND)	61(T)	110(T)
	3	2	F	610(T)	420	440
	4	1	F	110(ND)	43(T)	60(ND)
	4	1	D	140(ND)	32(T)	78(ND)
	4	2	F	310(T)	280	190(T)
	5	1	F	0(ND)	42(T)	63(ND)
	5	2	F	180(ND)	180	170(T)
	6	1	F	300(T)	35(T)	110(T)
	6	2	F	250(T)	270	130(T)

(continued)

TABLE 106. (cont'd.)

	Location	Day	Field (F)/ Duplicate (D)	Concentration[a] (ng/m^3)			
				Si	Ca	Fe	Pb
Elderly Home-2	1	1	F	110(ND)	56(T)	140(T)	310
	1	2	F	120(ND)	75(T)	110(ND)	62(ND)
	1	3	F	170(ND)	79(T)	130(T)	0(ND)
	2	1	F	470(T)	250	270(T)	400
	2	2	F	280(T)	190	190(T)	140(T)
	2	3	F	130(ND)	72(T)	120(T)	160(T)
	3	1	F	680(T)	110(T)	1900	65(ND)
	3	2	F	1440	750	790	400
	3	2	D	190(ND)	160	130(T)	100(T)
	3	3	F	480(T)	450	190(T)	0(ND)
	4	1	F	210(ND)	71(T)	120(T)	70(T)
	4	2	F	520(T)	220	300(T)	170(T)
	4	3	F	500(T)	230	1400	0(ND)
	5	1	F	0(ND)	0(ND)	74(ND)	0(ND)
	5	2	F	300(T)	400	110(ND)	31(ND)
	5	3	F	140(ND)	0(ND)	100(ND)	0(ND)

[a] Actual reported value is given. (ND) denotes that the value was below the LOD determined from the blank filter; (T) denotes that the value was between the LOD and QL.

TABLE 107. AVERAGE CONCENTRATIONS OF SELECTED ELEMENTS BY LOCATION WITHIN SITE: OFFICE TRIPS 1,2,3 AND ELDERLY HOME-2

	Concentration (ng/m^3)								
	Si			Ca			Fe		
Office Location	Trip 1	Trip 2	Trip 3	Trip 1	Trip 2	Trip 3	Trip 1	Trip 2	Trip 3
1. 1st floor office	1100	T[a]	T	1400	300	360	T	T	T
2. 1st floor secretarial	1300[b]	T	T	1500	T	86[b]	360	ND[c]	ND
3. 2nd floor office	T	T	T	970	150	250[b]	T	ND	330[b]
4. 2nd floor secretarial	1700	T	T	1900	96[b]	150[b]	380[b]	ND	T
5. 3rd floor copier	1100	T	ND	1500	310	130[b]	T	5900	T
6. Outside	1500	1800	T	280	310	170[b]	350[b]	370[b]	T

Elderly Home-2 Location	Si	Ca	Fe	Pb
1. 1st floor common area	ND	T	T	130[b]
2. 3rd floor non-smoker	T	180[b]	T	230[b]
3. 5th floor unoccupied	730[b]	370[b]	810[b]	150[b]
4. 8th floor smoker	T	180[b]	630[b]	T
5. Outside	T	150[b]	ND	ND

Sample sizes: 1, 2, or 3 for each office location;
3 or 4 for Elderly Home-2.

---

[a] All values trace or not detected.

[b] Some of the values were trace or not detected.

[c] All values not detected.

At the home, there were two isolated large iron concentrations reported, in the unoccupied and the smoker's apartments.

Table 108 presents the summary statistics for the school and elderly home-1, broken down by indoor/outdoor sample location and the type of "streaker" filter. The elements selected for data analysis were silicon, calcium, iron, bromine, and lead. Median QLs were computed as for Table 105, based on one set of LODs for each building and filter type. Because the samples were each taken over a four hour period at the school and over a one hour period at the home, one cannot really compare the two buildings. Looking for indoor versus outdoor differences, one notices that at the home the concentrations of all the elements are somewhat higher outdoors than within the building. Lead collected on the coarse particulate filters was present at higher levels outdoors than in the school, as was iron to a lesser extent. Both types of filters registered concentrations of calcium higher in the school than outside. Bromine concentrations at the school and lead concentrations at both buildings were higher for the particulates collected on coarse filters.

To make full analytical use of the streaker-type data, it is helpful to look at plots, for individual filters, of concentrations over time. Graphs for the school are in Figures 41-47. Each figure consists of four plots, one for each of the sampling locations, illustrating all of the data for a given element and filter type. Plots for the second floor show separate curves for the field and duplicate samples.

One is struck immediately by the strong periodicity of the curves for silicon, calcium, and iron at the second and fourth floor monitoring locations at the school and on the ground floor (for which levels are generally lower). Concentrations are above quantifiable limits only in the daytime and peak sharply around midday. This pattern is absent from the samples taken on the rooftop. The only notable feature of the rooftop plots of silicon and calcium concentrations is an isolated peak about noon of day 3; the plots of iron also show high levels from the evening of day 2 through the early morning of day 3. Lead and bromine concentrations followed a different pattern. The highest concentration occurred outdoors, during the early morning of day 2 and the morning of day 3. Ground floor concentrations were below QL, but lead concentrations on the other two

TABLE 108. SUMMARY STATISTICS FOR CONCENTRATIONS OF ELEMENTS BY BUILDING, INDOOR/OUTDOOR, AND METHOD: "STREAKER" FILTERS

		Concentration (ng/M³)							
		Fine Particulate				Coarse Particulate			
		School		Elderly Home-1		School		Elderly Home-2	
Element	Statistic[a]	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
Si	Mean	300	260	42[b]	62[b]	260	330[b]	31[b]	87
	Median	270	250	28	42	150	330	17	70
	Std. Dev.	210	120	38	45	190	0	23	31
	Max.	800	590	180	210	820	330	83	190
	Median QL[c]	190	130	210	340	740	520	88	130
Ca	Mean	190	82	20	42[b]	110	49	9.3	37
	Median	100	59	13	39	57	40	5.3	31
	Std. Dev.	190	65	18	27	110	20	8.4	13
	Max.	900	270	77	96	410	93	36	75
	Median QL	100	71	94	150	91	64	39	58
Fe	Mean	68	92	10	32	73	110	17[b]	39
	Median	56	79	4.4	24	59	100	8.9	38
	Std. Dev.	44	36	8.7	51	42	46	11	6.3
	Max.	170	190	58	450	180	200	42	55
	Median QL	32	23	30	49	82	57	48	71
Br	Mean	4.3[b]	4.1[b]	3.2[b]	4.6[b]	17	29	5.5[b]	9.5[b]
	Median	3.1	4.1	2.9	4.0	18	13	3.4	4.8
	Std. Dev.	2.9	2.8	1.4	2.2	7.3	23	4.7	6.3
	Max.	9.6	6.8	16	20	33	69	24	20
	Median QL	15	11	24	38	29	20	25	38

(continued)

TABLE 108. (cont'd.)

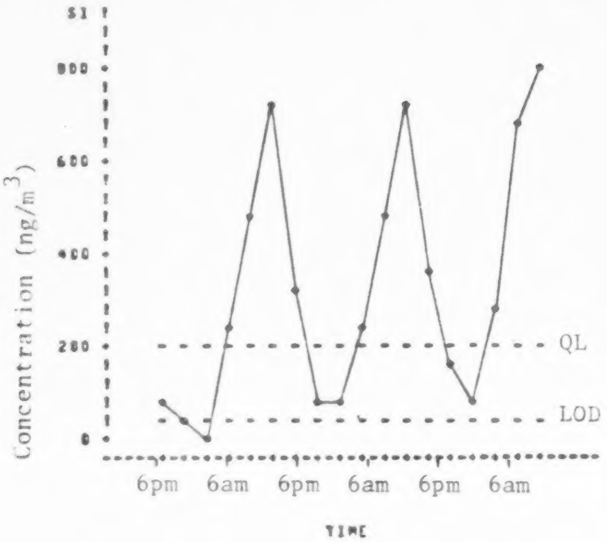
		Concentration (ng/m^3)							
		Fine Particulate				Coarse Particulate			
		School		Elderly Home-1		School		Elderly Home-2	
Element	Statistic[a]	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
Pb	Mean	5.8[b]	8.4	5.8[b]	9.2[b]	57	160	11[b]	28
	Median	4.5	3.2	5.7	7.7	47	130	6.6	26
	Std. Dev.	4.6	8.5	0.7	5.5	44	120	9.7	17
	Max.	37	29	6.9	39	200	340	42	66
	Median QL	36	25	45	73	36	25	49	73
	Sample Size	54	12	264	72	54	12	312	72

[a] If value below LOD, 1/2 LOD used in calculations instead of reported value. If value above LOD but below quantifiable limit, 5/8 of quantifiable used.

[b] All values below quantifiable limit.

[c] Median of the quantifiable limits for all observations.

Concentrations at School - 4th Floor



Concentrations at School - Rooftop

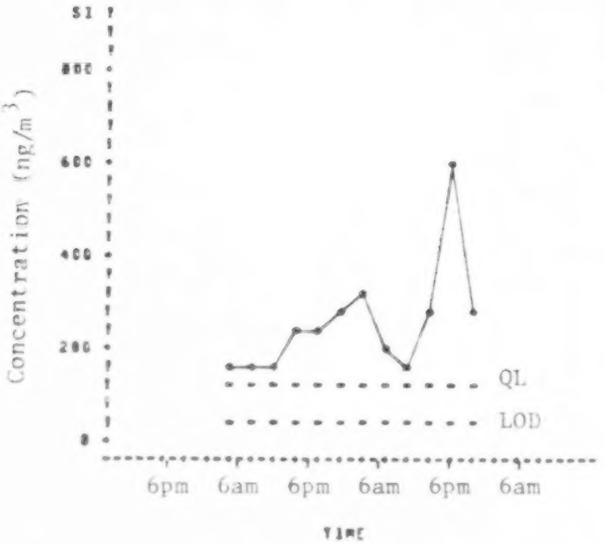
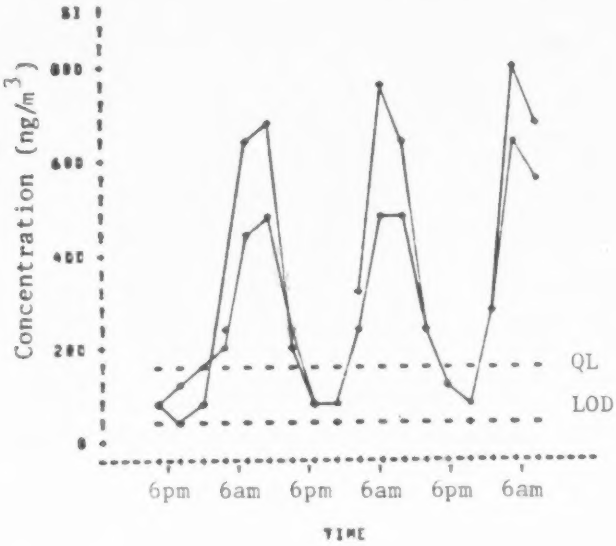


Figure 41. Concentrations of silicon found on the fine particulate filter samples from the school. (continued)

Concentrations at School - 2nd Floor



Concentrations at School - Ground Floor

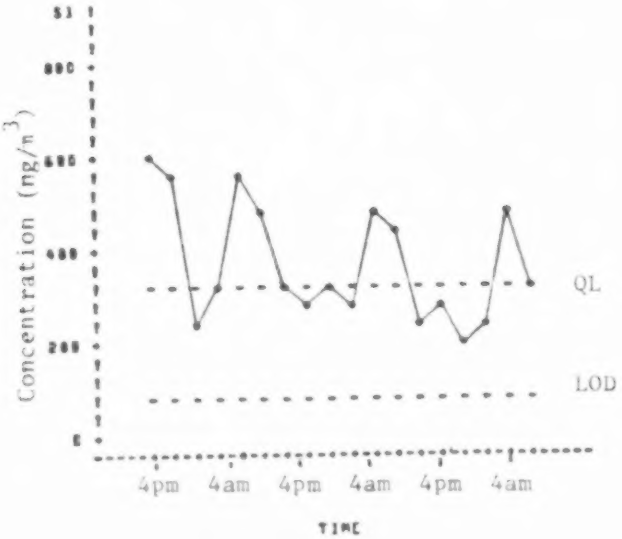
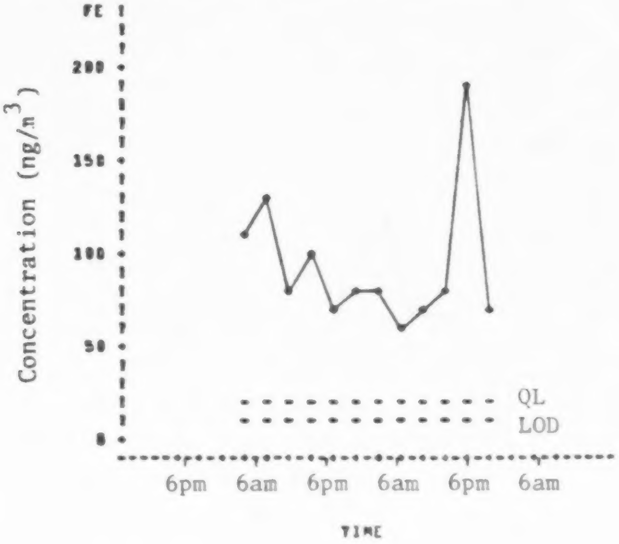


Figure 41 (continued)

Concentrations at School - Rooftop



Concentrations at School - 4th Floor

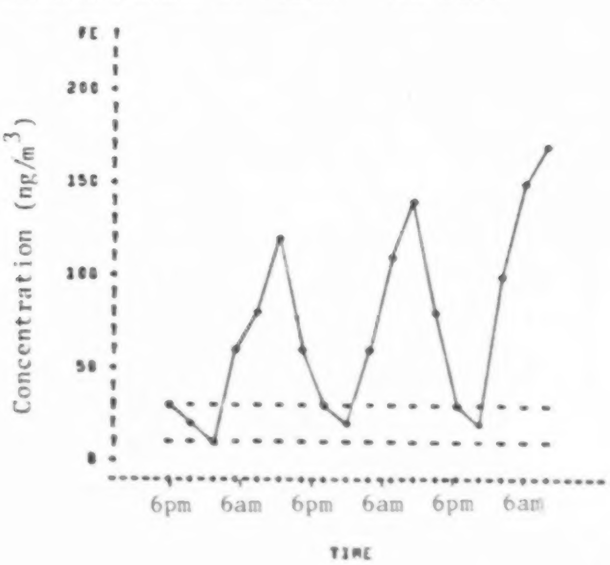
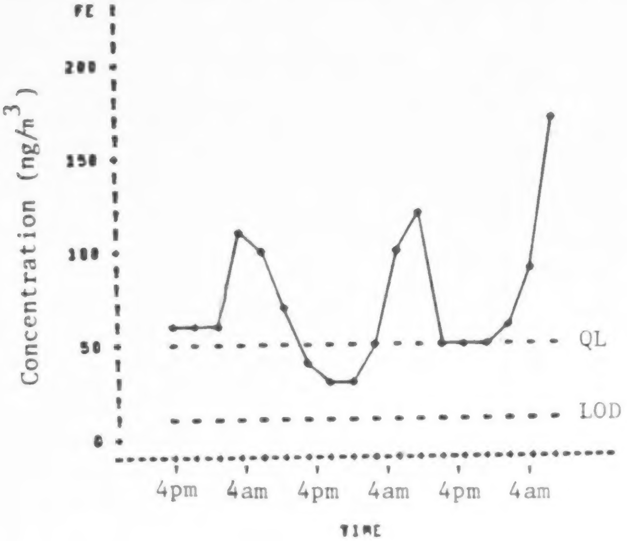


Figure 42. Concentrations of iron found on the fine particulate filter samples from the school. (continued)

Concentrations at School - Ground Floor



Concentrations at School - 2nd Floor

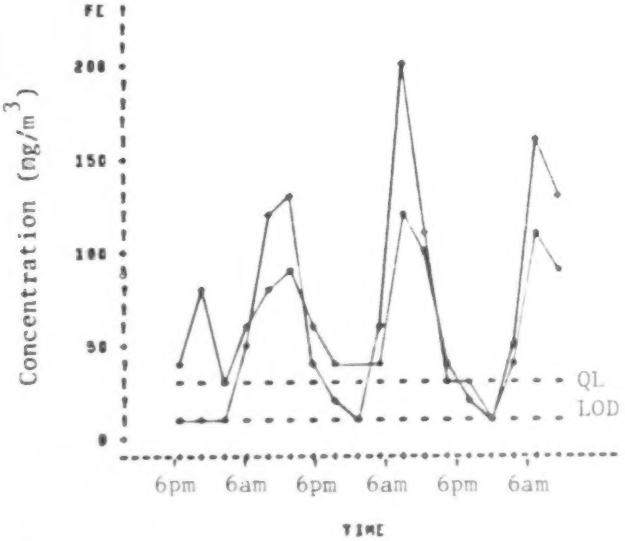
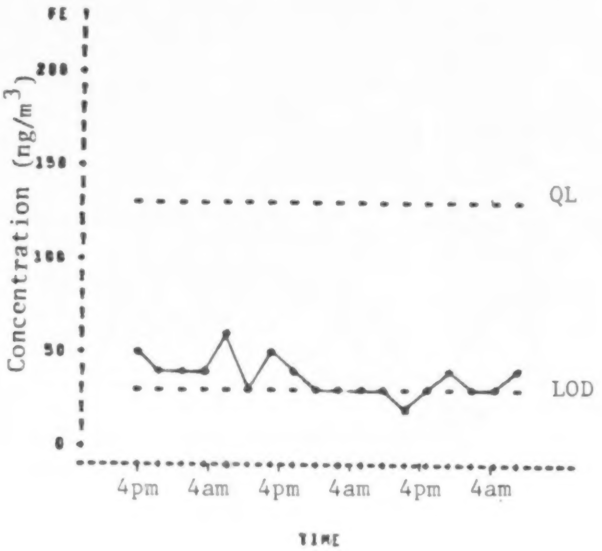


Figure 42 (continued)

Concentrations at School - Ground Floor



Concentrations at School - 2nd Floor

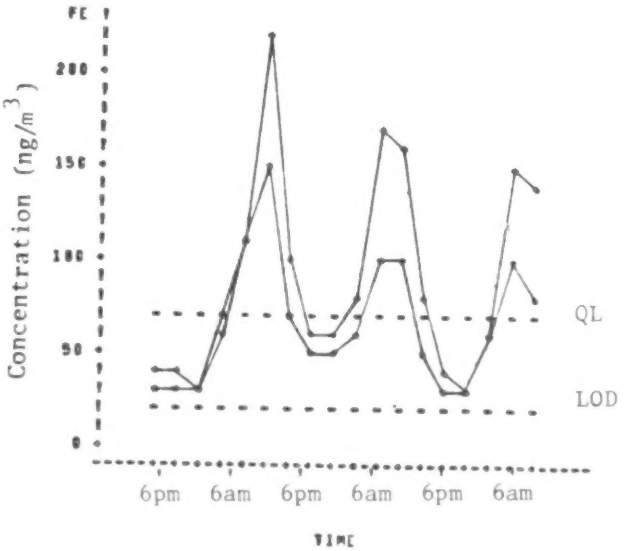
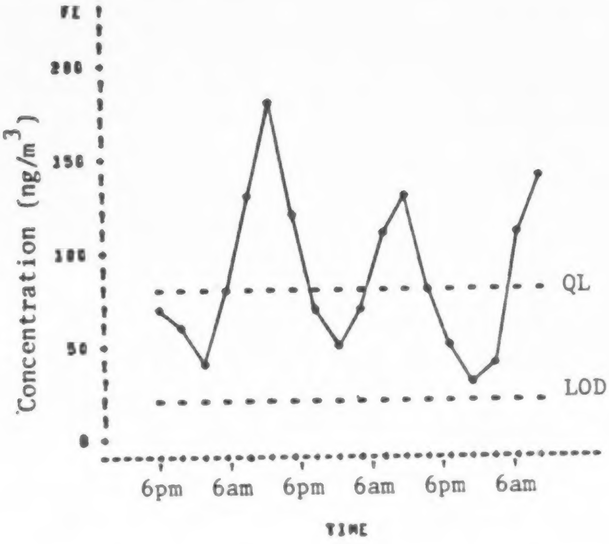


Figure 43. Concentrations of iron found on the coarse particulate filter samples from the school. (continued)

Concentrations at School - 4th Floor



Concentrations at School - Rooftop

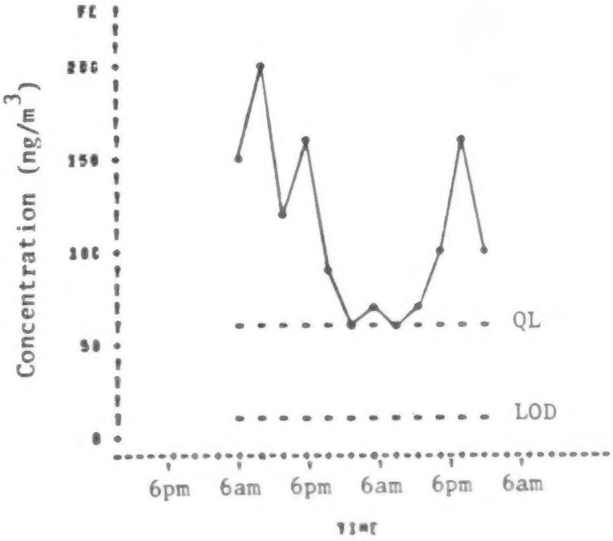
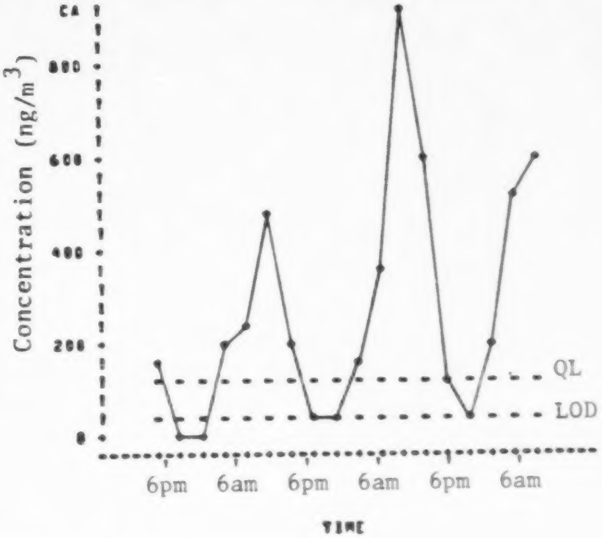


Figure 43 (continued)

Location - 4th Floor



Location - Rooftop

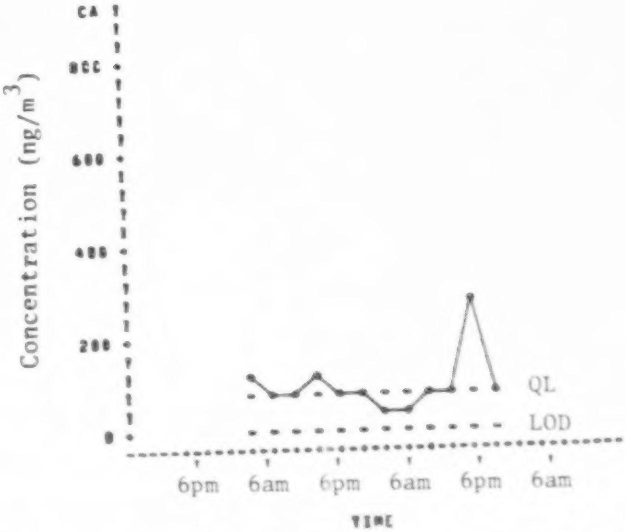
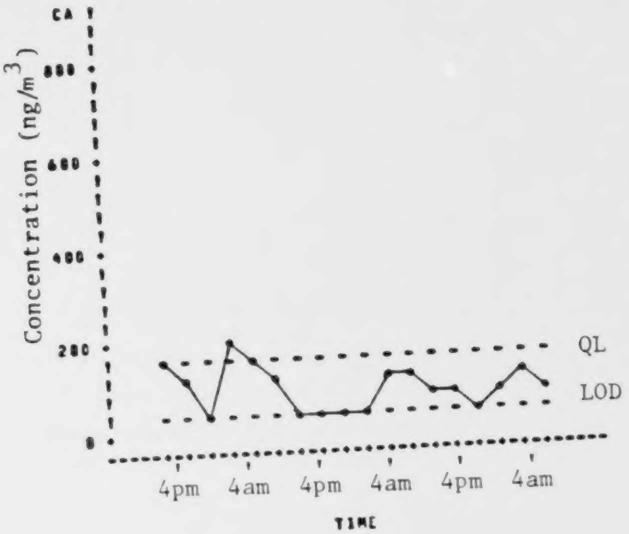


Figure 44. Concentrations of calcium found on the fine particulate filter samples from the school. (continued)

Location - Ground Floor



Location - 2nd Floor

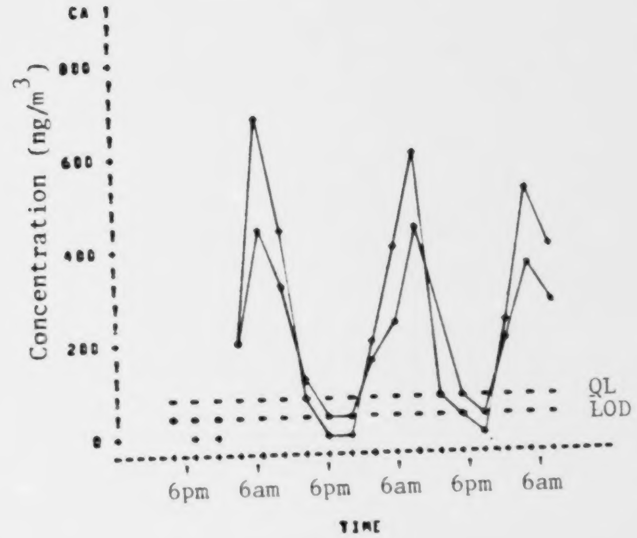
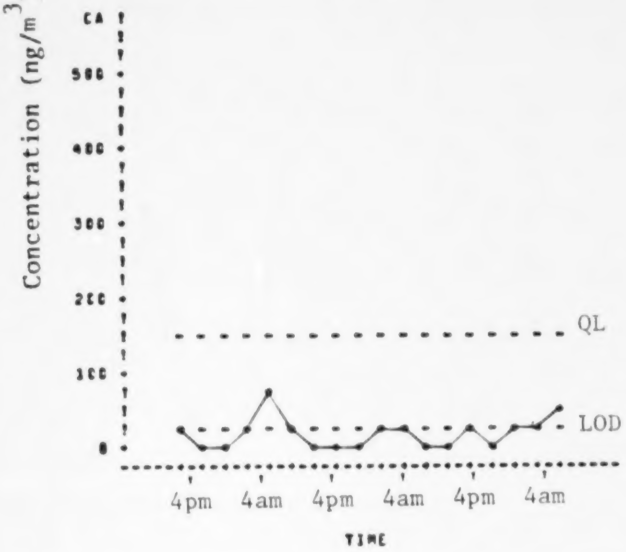


Figure 44 (continued)

Concentrations at School - Ground Floor



Concentrations at School - 2nd Floor

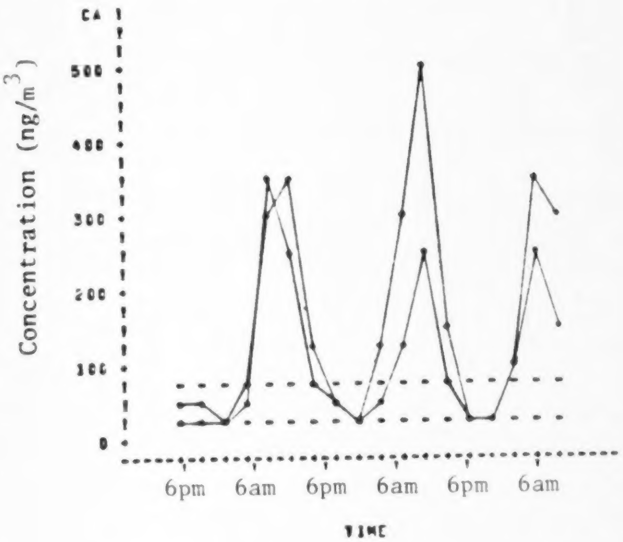
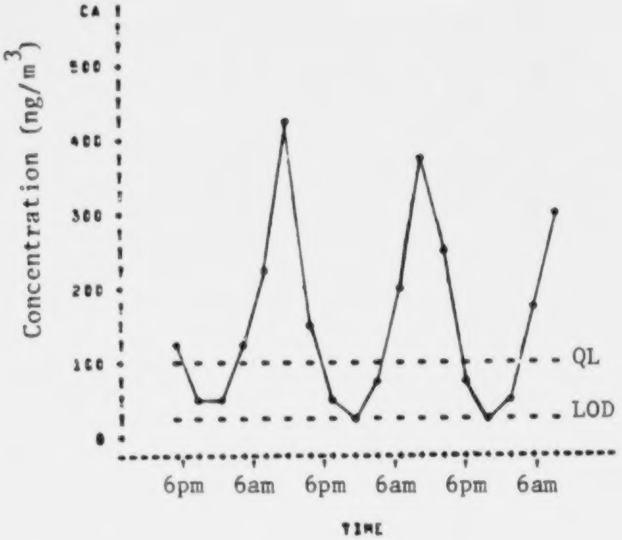


Figure 45. Concentrations of calcium found on the coarse particulate filter samples from the school. (continued)

Concentrations at School - 4th Floor



Concentrations at School - Rooftop

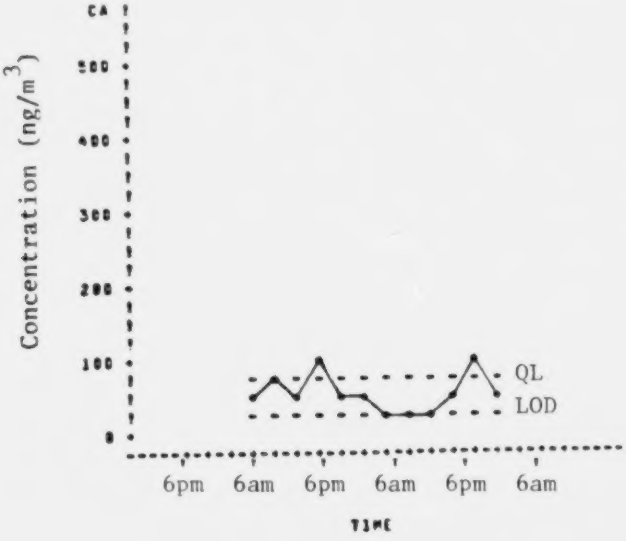
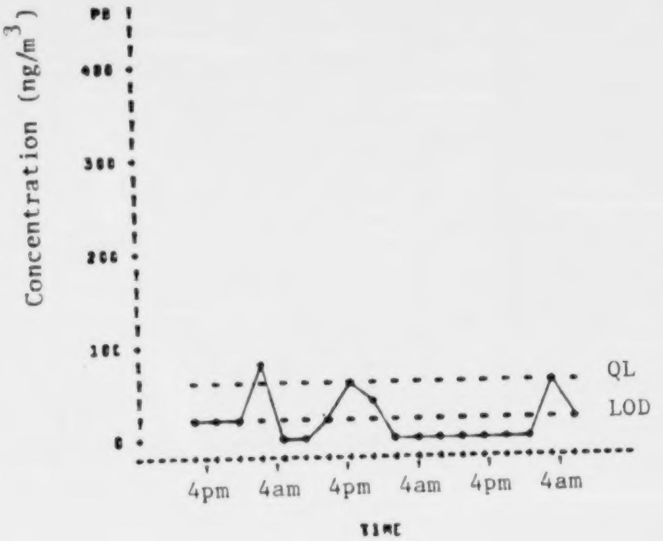


Figure 45 (continued)

Concentrations at School - Ground Floor



Concentrations at School - 2nd Floor

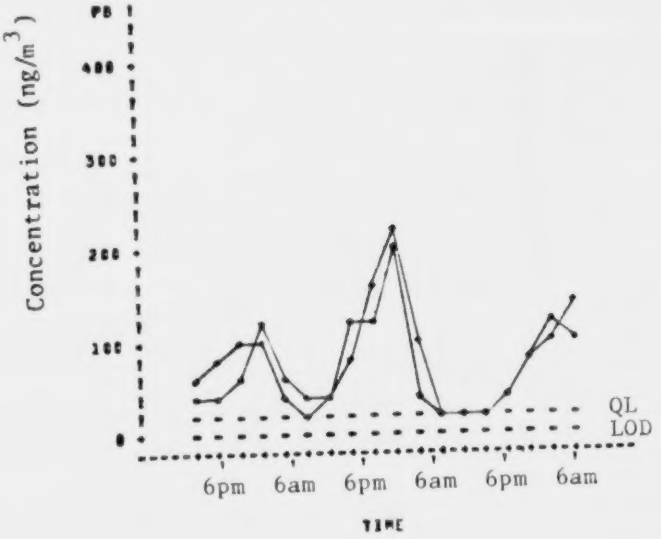
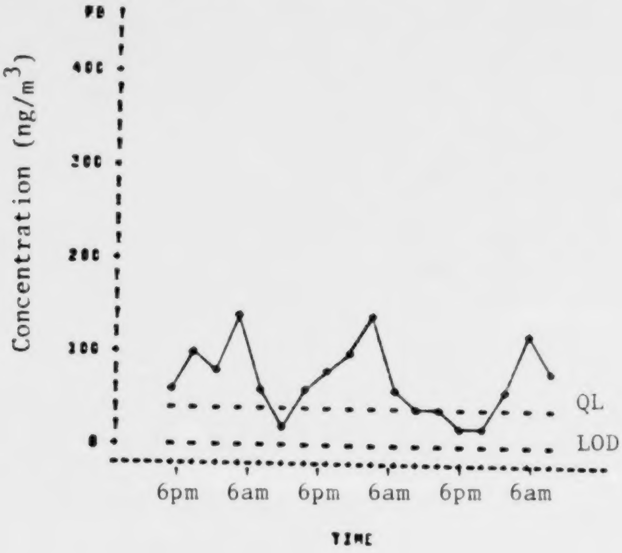


Figure 46. Concentrations of lead found on the coarse particulate filter samples from the school. (continued)

Concentrations at School - 4th Floor



Concentrations at School - Rooftop

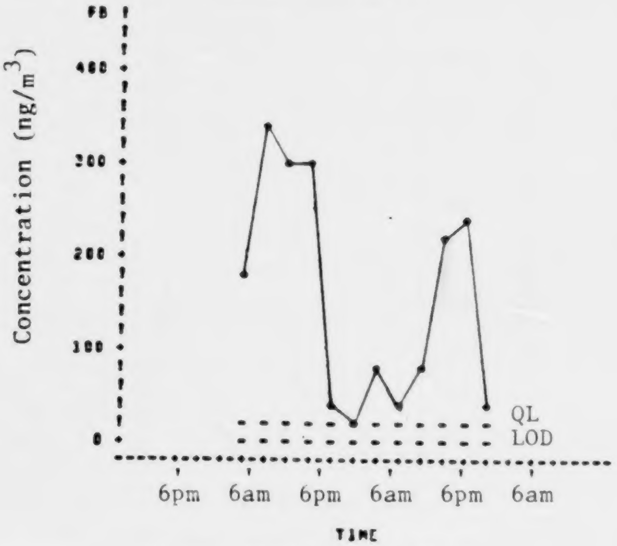
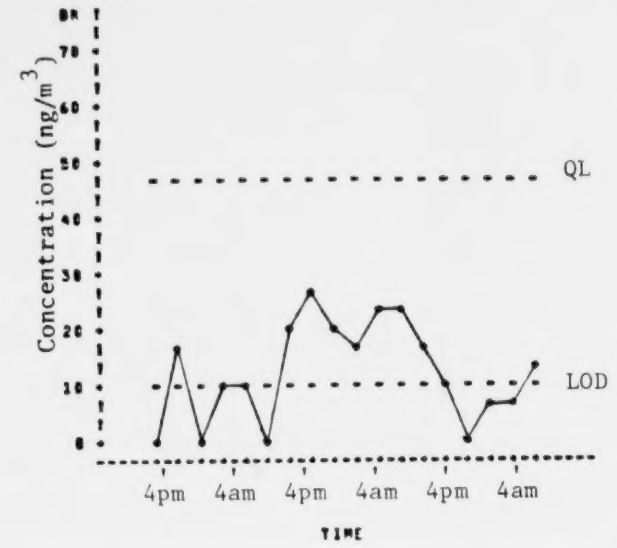


Figure 46 (continued)

Concentrations at School - Ground Floor



Concentrations at School - 2nd Floor

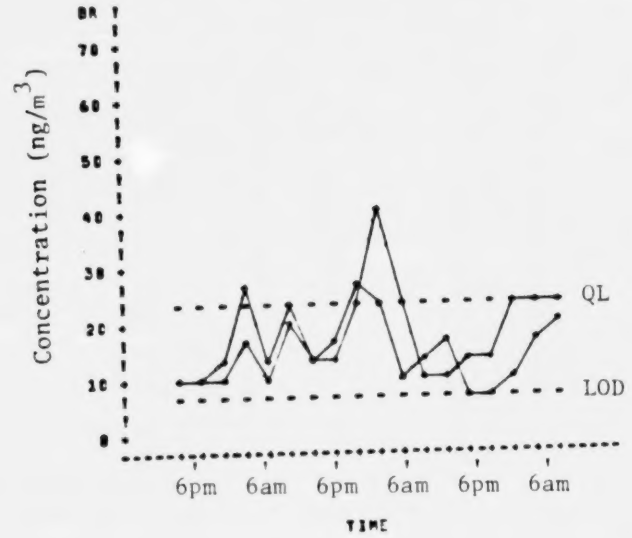
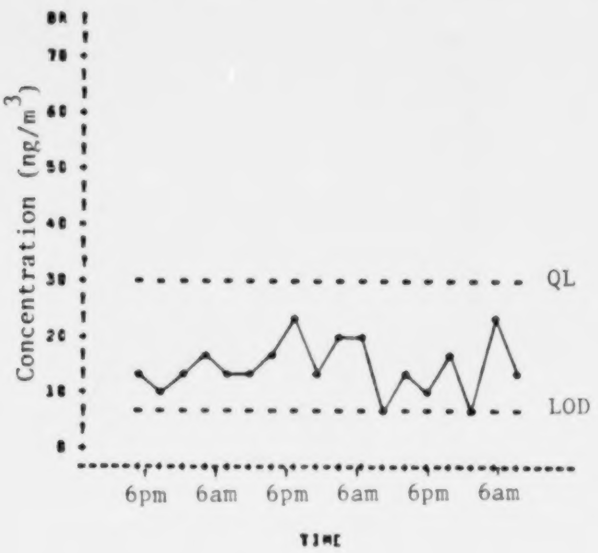


Figure 47. Concentrations of bromine found on the coarse particulate filter samples from the school. (continued)

Concentrations at School - 4th Floor



Concentrations at School - Rooftop

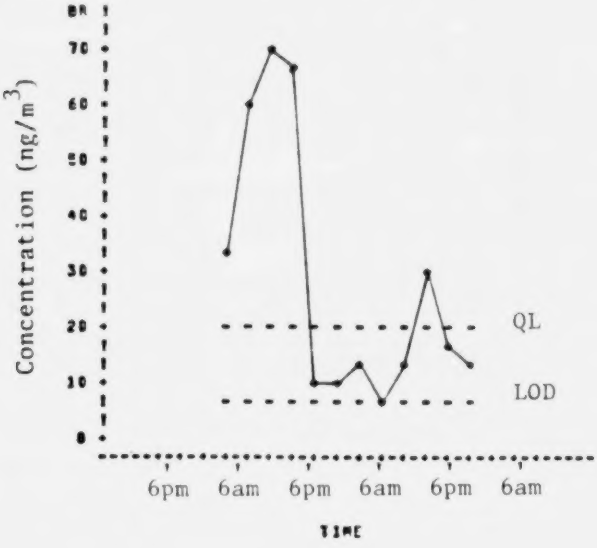


Figure 47 (continued)

floors peaked at about 6-10 a.m. on the first two days and in the afternoon on the third day. Bromine concentrations on the second floor followed the same pattern.

Figures 48-52 are plots of silicon, calcium, iron, and lead concentrations versus time for the samples collected on the rooftop of the elderly home-1. The duplicate sample was collected for the second and third days only. The data are clearly "noisy", and mostly below QL, but careful examination reveals that most of the peaks occur around 11 a.m. and 11 p.m. Lead and iron concentrations on the third day were at their highest levels about 4 p.m. rather than 11 a.m.

In summary, the only elements consistently detected at measurable levels were "crustal" ones such as silicon, calcium, and iron. Whether they were more prevalent indoors or outdoors varied by trip and building. For the office building, concentrations were highest on the first trip, and very low by the third trip. Levels and percent measurable were generally very low at both elderly homes. The most interesting data were from the school where silicon, calcium, and iron were measurable indoors only in the daytime, but lead and bromine followed an entirely different pattern and were found mainly outdoors.

NITROGEN DIOXIDE

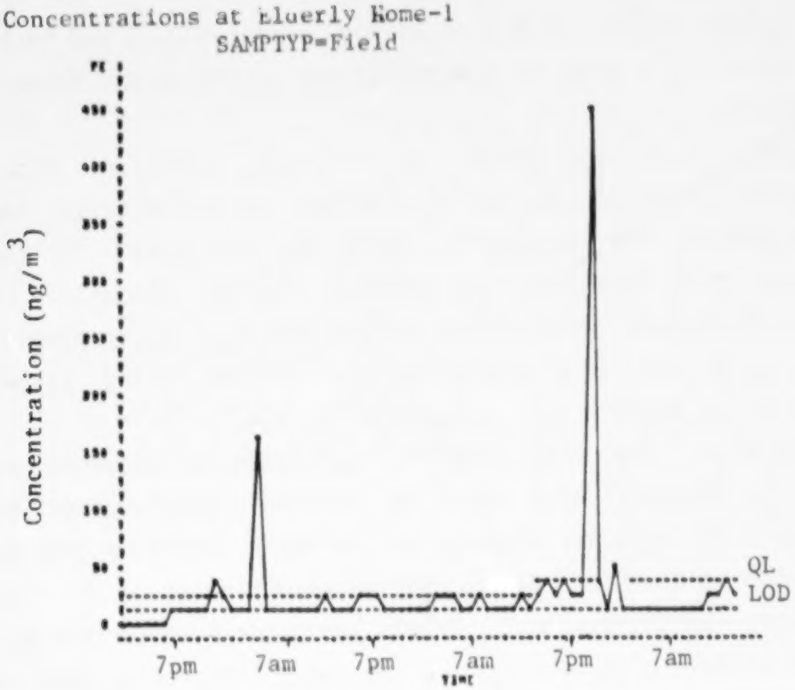
Chemiluminescent NO/NO_x Gas Analyzer

Field data generated using the Bendix 8101-C Chemiluminescent monitor were completed for the two sample locations monitored at the elderly home-1. Results presented as hourly averages (PPM) are complied in Table 109 and 110. This was the only field monitoring trip where NO_2 analysis was performed.

NO_2 Badges

Badge type personal samples were exposed during the same time the chemiluminescent analyzers were operating. Results were calculated as daily mean averages of NO_2 for the 24 hour exposure period.

Data for each badge are shown in Table 111. This table also gives results for the chemiluminescent analyzer calculated as a daily mean average. Comparison of badge values with analyzer values are fairly good for the outdoor sampling location 1. In contrast, data for location 2 (the 5th floor lounge) showed poor agreement between the two techniques.



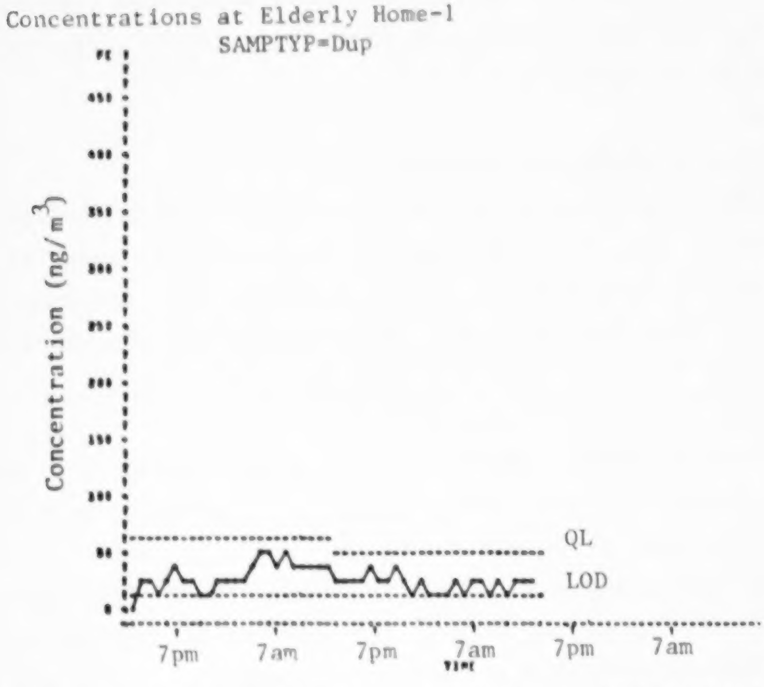
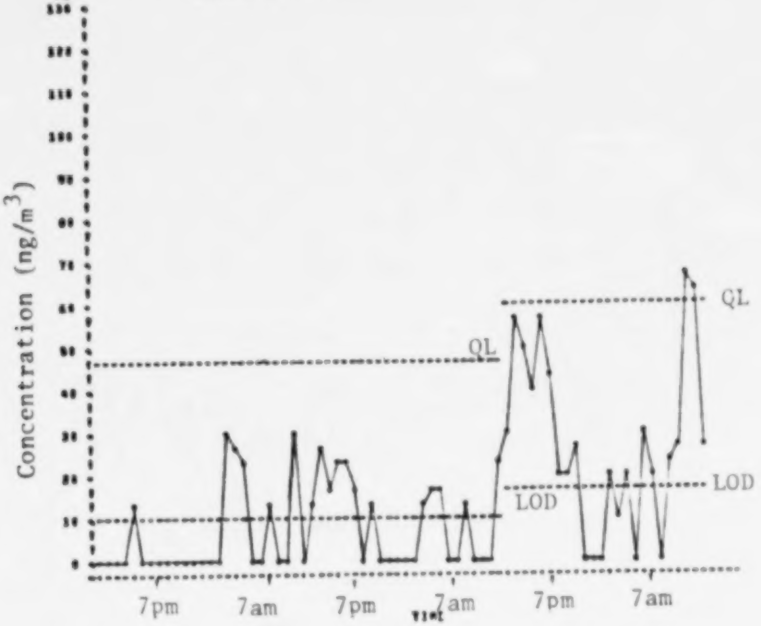


Figure 48. Concentration of iron found on the fine particulate filter samples collected at the outdoor location at the elderly home-1.

Concentrations at Elderly Home-1 - Outside
SAMPTYP=Field



Concentrations at Elderly Home-1 - Outside
SAMPTYP=Dup

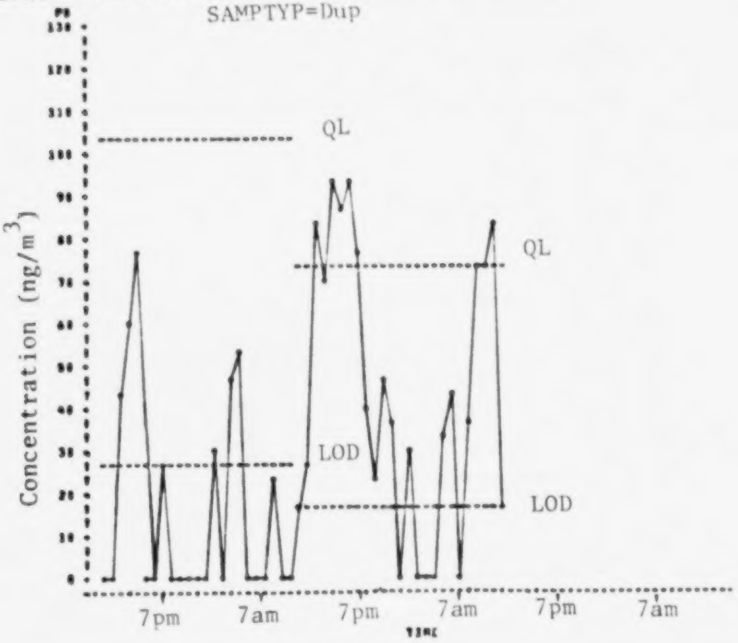
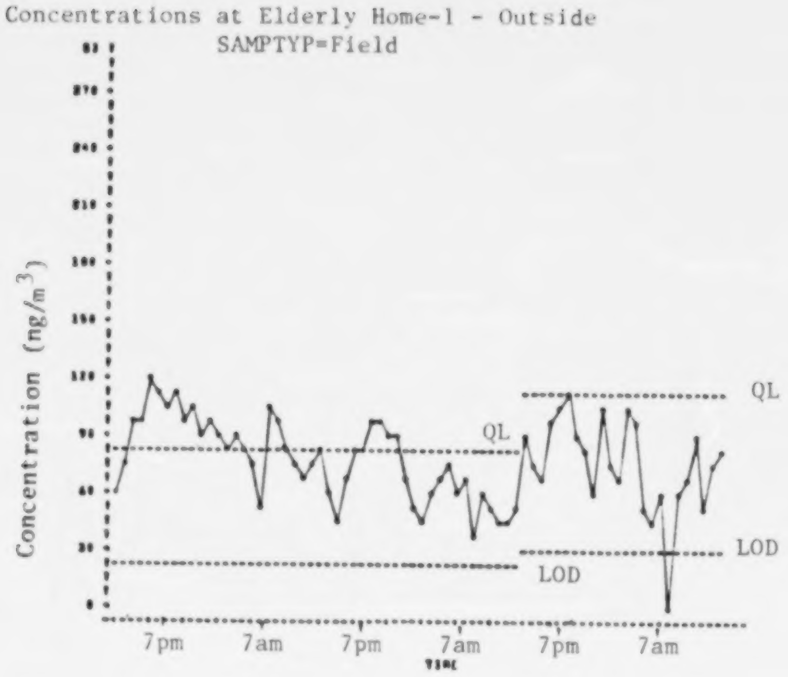


Figure 49. Concentration of lead found on the coarse particulate filter samples collected at the outdoor location at the elderly home-1.


Concentrations at Elderly Home-1 - Outside
SAMPTYP=Field

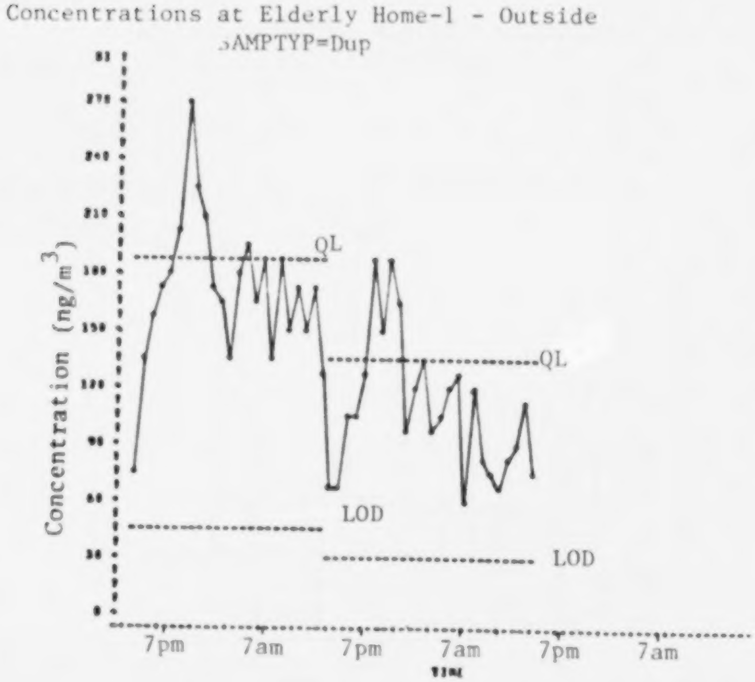
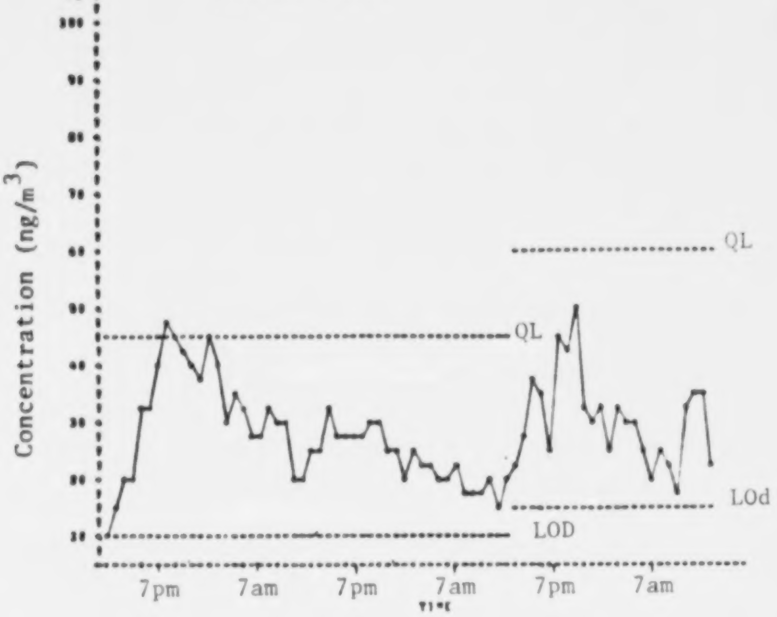

Concentrations at Elderly Home-1 - Outside
SAMPTYP=Dup

Figure 50. Concentrations of silicon found in the coarse particulate filter samples collected at the outdoor location at the elderly home-1.

Concentrations at Elderly Home-1 - Outside
SAMPTYP=Field



Concentrations at Elderly Home-1 - Outside
SAMPTYP=Dup

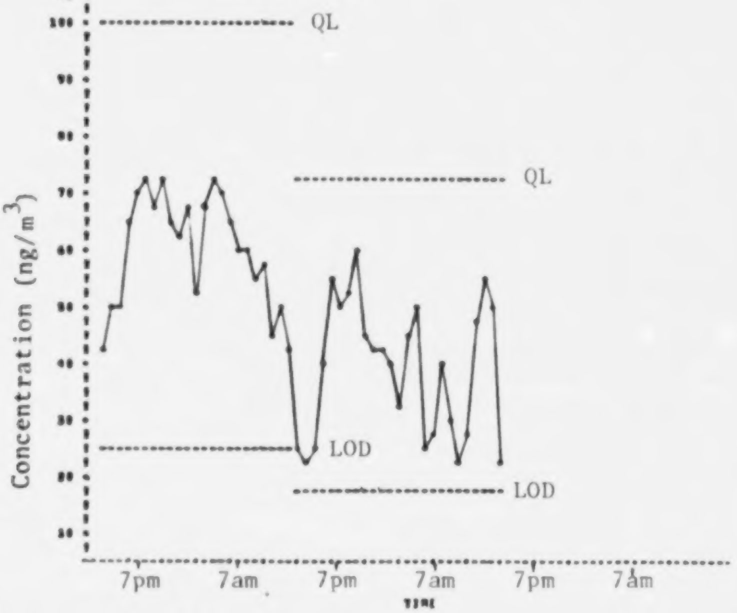
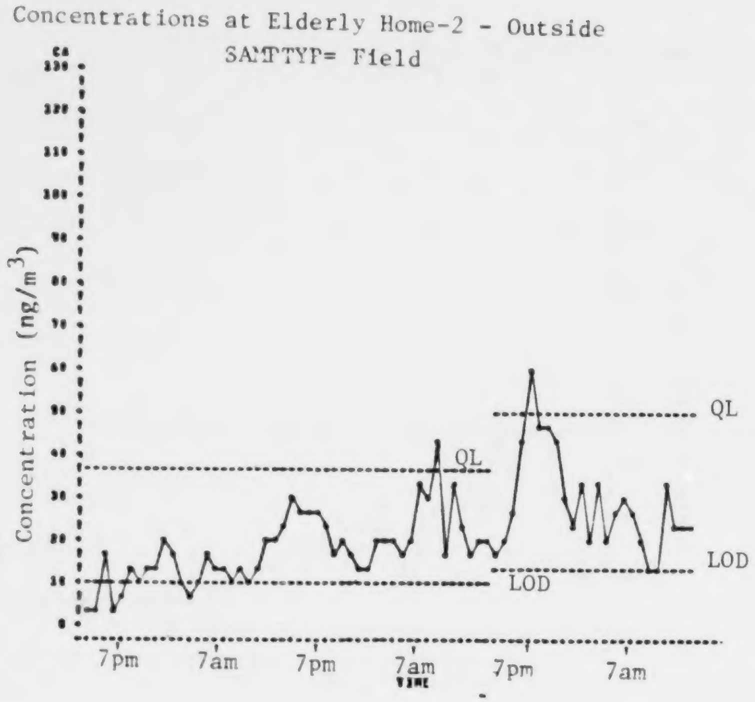


Figure 51. Concentration of iron found on the coarse particulate filter samples collected at the outdoor location at the elderly home-1.



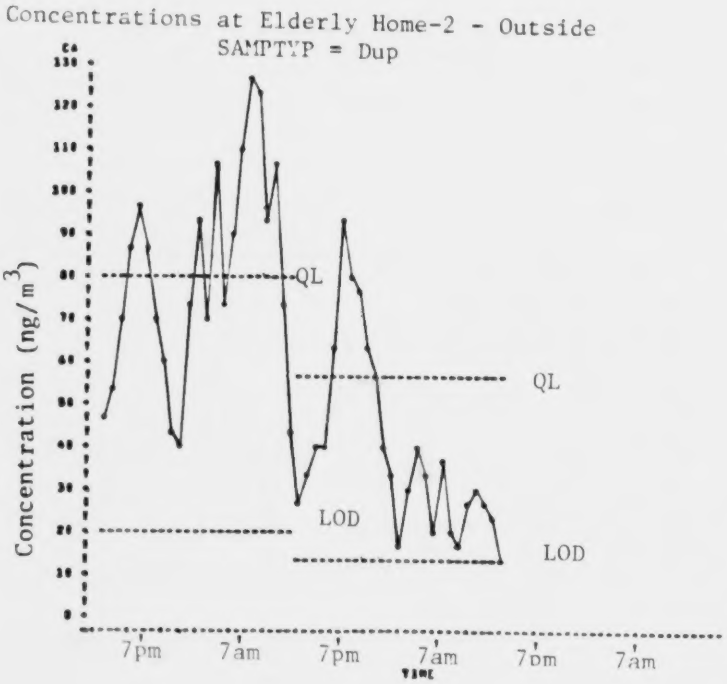


Figure 52. Concentration of calcium found on the coarse particulate filter samples collected at the outdoor location at the elderly home-1.

TABLE 109. MEASURED NO_2 CONCENTRATION AT SAMPLE LOCATION 1 (OUTDOORS) IN THE ELDERLY HOME-1

	$[NO_2]$ (ppm)			
Time (hr)	3/23	3/24	3/25	3/26
0000		0.015	0.015	0.041
0100		0.014	0.010	0.033
0200		0.015	0.009	0.027
0300		0.014	0.010	0.022
0400		0.014	0.012	0.021
0500		0.014	0.016	0.028
0600		0.019	0.020	0.027
0700		0.021	0.023	0.023
0800		0.026	0.024	0.017
0900		0.018	0.016	0.017
1000		0.017	0.014	0.020
1100		0.013	0.013	0.025
1200		0.015	0.012	0.021
1300		0.020	0.012	0.022
1400		EPA Audit	0.012	0.038
1500			0.013	0.049
1600		0.020	0.015	0.045
1700		0.026	0.019	0.034
1800	0.016	0.028	0.036	
1900	0.021	0.032	0.042	
2000	0.025	0.038	0.045	
2100	0.025	0.042	0.044	
2200	0.022	0.035	0.042	
2300	0.022	0.021	0.039	

TABLE 110. MEASURED NO_2 CONCENTRATION AT SAMPLE LOCATION 2 (5TH FLOOR LOUNGE) IN THE ELDERLY HOME-1

	$[NO_2]$ (ppm)			
Time (hr)	3/23	3/24	3/25	3/26
0000		0.019	0.026	0.025
0100		0.016	0.021	0.025
0200		0.016	0.020	0.023
0300		0.015	0.017	0.019
0400		0.015	0.019	0.017
0500		0.017	0.022	0.020
0600		0.018	0.024	0.022
0700		0.020	0.026	0.021
0800		0.024	0.023	0.025
0900		0.025	EPA Audit	0.026
1000		0.024	0.021	0.026
1100		0.026	0.022	0.025
1200		0.026	0.017	0.024
1300		0.027	0.016	0.022
1400		0.029	0.016	0.024
1500		0.027	0.015	0.031
1600		0.028	0.015	0.033
1700	0.015	0.035	0.018	0.035
1800	0.018	0.035	0.023	
1900	0.021	0.031	0.025	
2000	0.021	0.031	0.026	
2100	0.024	0.034	0.028	
2200	0.023	0.035	0.028	
2300	0.021	0.031	0.026	

TABL 111. MEASURED NO_2 CONCENTRATION AT THE ELDERLY HOME-1

	Daily Mean Average $[NO_2]$ (ppb)	
Sample Code	Badge[a]	NO_x Monitor
131-3 NO-F1[b]	16.5	18.7
131-3 NO-F2[b]	17.2	19.2
131-3 NO-D2[b]	15.3	--
131-3 NO-F3[b]	23.1	31.1
132-1 NO-F1[c]	13.1	23.0
132-1 NO-D1[c]	15.7	--
132-1 NO-F2[c]	13.3	22.7
132-1 NO-F3[c]	21.3	25.0

[a] Corrected for background present in FB-1 (2.27 ppb NO_2).

[b] Outdoor location.

[c] Indoors - fifth floor lounge.

It is hypothesized that poor agreement between the two methods for the indoor location may be due to effects of air stagnation or positive interferences affecting the chemiluminescent monitor.

CARBON MONOXIDE

Field data generated using the General Electric carbon monoxide monitors were compiled for three sampling locations monitored at the elderly home-1. Results (as 12 hr averages) are presented in Table 112. Because there was no detectable carbon monoxide at any sampling sites and because of the problems associated with operating the CO monitors in the field under conditions of low humidity and high static electricitiy, CO was not monitored on any other field trips.

AIR EXCHANGE RATES

In parallel with sampling air for various pollutants, several air exchange rate determinations were conducted by releasing sulfur hexafluoride (SF_6) into the air.

Results of air exchange measurements made at the elderly home-1, the school, and the office building trips 1 and 2 are given in Tables 113 and 114. Data are presented as changes per hour which were calculated from the derived linear relationship between chromatographic peak height and time. In most cases, the analyses showed a definite linear relationship which allowed the calculation of an air exchange rate. Where linearity could not be established, a calculation was not made.

Overall, the exchange rate data for the elderly home-1 (Table 113) showed some similarities between locations. The 3rd and 5th floor locations show similar patterns of air exchange throughout the sampling periods, whereas other locations were more variable. Since the 3rd and 5th floor locations are located in the same wing and are affected by the same air handling system, this would be expected. The 4th floor location is located in the other wing. Unfortunately, since only a few exchange rates were determined at this location, no corresponding pattern emerged.

Air exchange data for the school are given in Table 114. The ventilation system for the school was microprocessor controlled and during off-use hours the system was shut off providing little or no ventilation. To better ascertain the ventilation characteristics of the building, the release of SF_6 and collection of air samples during the first period was

TABLE 112. CARBON MONOXIDE CONCENTRATIONS MEASURED AT THE ELDERLY HOME-1

Sample Site	Sample Type	Sample Time (Hrs)	CO, ppm
2	field	0-12	NC[a]
		12-24	NC
		24-36	<5[b]
		36-48	ND[c]
		48-60	<5
		60-72	<5
4	field	0-12	<5
		12-24	<5
		24-36	<5
		36-48	ND
		48-60	<5
		60-72	ND
4	duplicate	0-12	0
		12-24	<5
		24-36	<5
		36-48	ND
		48-60	<5
		60-72	<5
5	field	0-12	NC
		12-24	NC
		24-36	ND
		36-48	ND
		48-60	<5
		60-72	ND

[a] Not calculated, baseline dropped below zero.

[b] Estimated baseline rose above zero but less than 5 ppm.

[c] Not detected.

TABLE 113. MEASURED AIR EXCHANGE RATES AT THE ELDERLY HOME-1

Location	Air Exchange Rate (changes/h)				
	Period 1[a]	Period 2	Period 3	Period 4	Period 5
5th floor lounge	2.3	1.6	2.3, 2.3[b]	1.7	1.7
3rd floor lounge	1.7, 1.9[b]	1.5	2.2	1.8	2.3
2nd floor dining room	1.0	NS[c]	NC[d]	1.6	1.1
4th floor non-smoker apartment	NS	NS	1.1	NC	1.7, 2.0[b]

[a] Period 1 - 3/24/83 AM; Period 2 - 3/24/83 PM; Period 3 - 3/25/83 AM; Period 4 - 3/25/83 PM; Period 5 - 3/26/83 AM.

[b] Duplicates.

[c] Samples not collected.

[d] Exchange rate not calculated.

TABLE 114. MEASURED AIR EXCHANGE RATES AT SCHOOL

	Air Exchange (changes/h)					
Location	Period 1[a]	Period 2	Period 3	Period 4	Period 5	Period 6
1st floor Zone 3	1.0	1.0	.75	1.2	.90	NS[b]
2nd floor Zone 3	1.0	0.9	.18	NC[c]	.67	.79
4th floor	1.1	1.3	.16, .22	.92, .66	.67	1.16

[a] Period 1 - 5/23/83 PM; Period 2 - 5/24/83 AM; Period 3 - 5/24/83 PM; Period 4 - 5/25/83 AM; Period 5 - 5/25/83 PM; Period 6 - 5/26/83 AM.

[b] Sample not collected.

[c] Exchange rate not calculated.

conducted with the ventilation on 100% of the time (manual mode). This was done during the early evening hours when the ventilation was normally not operating. The remaining collections of air samples occurred with the system operating normally (automatic mode).

The data shows an obvious correspondence between the first period when the ventilation was always on and the other periods in which the air samples were collected during the day (7 a.m. to 4 p.m.). The third period shows a marked decrease in the exchange rate after 4 p.m. as would be expected. A plot of the exchange rates over the course of the study is shown in Figure 53.

Results from the first trip to the office building are presented in Table 115.

Periods 2 and 4 represent morning periods when there was a high flux of people into and out of the building. This is reflected in the higher exchange rates during these periods. Period 3 represents an evening period during which there was little activity; hence a very low exchange rate. All sets of samples provided definite linear relationships with very good correlation coefficients.

Results for the second trip to the office (Table 116) show generally good agreement in exchange rates for samples collected throughout the building. Exchange rates for period 1 were higher than for the other three periods. The reason for this is unknown.

Results of exchange rate measurements from trip 3 to the office building showed unexpectedly poor and variable results. For example, correlation coefficients for most exchange rates calculated during previous sampling trips were greater than 0.94. For this trip many of the correlation coefficients were ~0.50 suggesting that random concentrations of SF_6 were being measured over time rather than measuring predictably decreasing SF_6 concentrations. Further air exchange rates calculated for the office building during sampling trip 1 and 2 were very similar between locations for a single time period. During this trip, disparate exchange rates were calculated between sites and for duplicate samples at a single site. The poor results of the exchange rate data could be due to several factors.

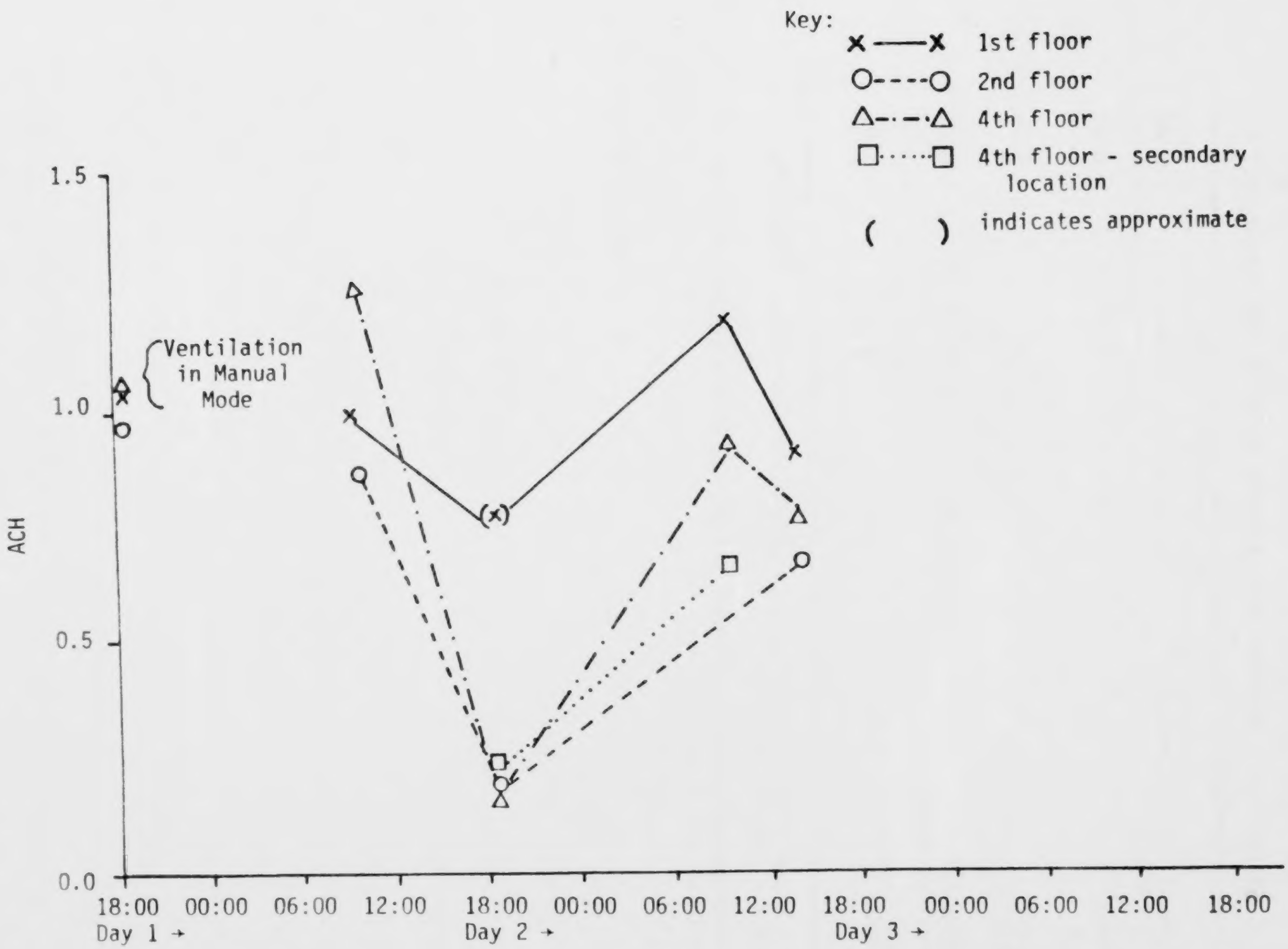


Figure 53. Air exchange rates over time of Merritt Elementary School (Washington, DC) - visit 1.

TABLE 115. MEASURED AIR EXCHANGE RATES AT THE OFFICE TRIP 1

Location	Air Exchange (changes/h)			
	Period 1[a]	Period 2	Period 3	Period 4
1st floor office	---[b]	0.73	0.27	0.83
2nd floor office	---	0.81	0.17	0.84
2nd floor secretarial area	---	0.80	0.22	0.87
3rd floor copier	---	0.65	0.24	0.92

[a] Period 1 - 6/28/83 pm; Period 2 - 7/28/83 am; Period 3 - 7/28/83 pm; Period 4 - 7/29/83 am.

[b] The ventilation system was turned off during this time period so no SF_6 release and collection was made.

TABLE 116. MEASURED AIR EXCHANGE RATES AT THE OFFICE TRIP 2

	Air Exchange Rate (changes/h)			
Location	Period 1[a]	Period 2	Period 3	Period 4
1st floor office	.63	.38	NC[b]	.32
2nd floor secretarial	.93	.54	.37	.34
3rd floor copier room	.90	NC	NC[c]	.28

[a] Period 1 - 9/6/83 PM; Period 2 - 9/7/83 AM; Period 3 - 9/7/83 PM; Period 4 - 9/8/83 AM.

[b] Exchange rate not calculated due to poor correlation sample, not collect duplicate.

[c] Sample not collected.

1. GC/ECD measurements of SF_6 concentration in each syringe could be in error. This is unlikely since calibration curves run before and after analyses were linear and similar. Also analysis of periodic check standards (100 ppb SF_6) showed no anomalies.
2. Building air flow and exchange rates could be dramatically different than during previous sampling trips. Since the visit was performed during a cold period in December as compared to past visits in the summer, it is possible that differences in the building ventilation system were responsible for anomalous results.
3. The samples were collected incorrectly. Since samples are collected by an automated process it is impossible to tell exactly what occurred during sampling. However comparison of duplicate sample collections showed very different concentrations of SF_6 in syringes which were located at the same site and were sampling air at the same time. This is, in fact, strong evidence that some aspect of the sampling procedure was in error.

Air exchange rates calculated from sample collections at the elderly home-2 were not usable for several reasons. First, there was a contaminant in the building air or in the syringes which coeluted with SF_6 making quantitation of the SF_6 in many of the samples impossible during GC/ECD analyses. Secondly, the air exchange rates at each sampling site were independently controlled and no predictable release of SF_6 was possible.

SECTION 9

QUALITY CONTROL AND QUALITY ASSURANCE

OFFICE BUILDING

Field Operations

A multi-story commercial office building located in the primarily rural Research Triangle Park area of central North Carolina was utilized as a rural collection site on three separate occasions: prior to occupancy (July 27 to July 29, 1983) and at two later times (September 6 to September 8, 1983; December 19 to December 21, 1984). Before the start of each study, a sampling schedule was prepared and distributed to the sampling personnel. This schedule was the same for each trip and is shown in slightly modified format in Table 117. Adherence to this schedule and any resulting sample losses were determined by performing a sample inventory audit (Tables 118 to 120). This information was compiled and completeness data calculated for the different sample types (Table 121). Completeness is defined as the percentage of samples scheduled for collection which were actually collected, analyzed, and for which target compound levels appear in the computer file.

Sample Analysis

The quality control procedures implemented for the determination of each target compound are discussed in Section 6.

Field Quality Control Samples

Volatile Organics--

The field controls from the first office building gave excessively high recoveries for five compounds (Table 122). Most of the target compounds had recoveries between 105 and 125%; five compounds were recovered in the 150-250% range. Only tetrachloroethylene (45%) exhibited a recovery below 100%. Benzene (58 ng/ cartridge) was the only target found in significant amounts on the field blanks.

TABLE 117. SAMPLING SCHEDULE - OFFICE BUILDING

		Analyte Type[a]					
		VO	RP	PP	FM	MN	AE
Day 1-Location	1	F1,2	F1;Q1[b]	F1;Q1	F1	F1	F1,2
	2	F1,2;Q1[b]	F1;D1[c]	F1[b]	F1;D1[c]	F1	-
	3	F1,2	F1	F1	F1;Q1[b]	F1	F1,2
	4	F1,2;D1[c]	-	F1;D1[c]	F1	F1;D1[c]	F1,2
	5	F1,2	-	F1	F1	F1;Q1[b]	F1,2
	6	F1,2;Q2	F1	F1	F1	F1	-
Day 2-Location	1	F3,4;Q3[b]	F2	F2	F2;Q2[b]	F2	F3,4;D3,4
	2	F3,4	F2	F2	F2	F2;Q2[b]	-
	3	F3,4;D4[c]	F2,Q2[b]	F2;D2	F2	F2	F3,4
	4	F3,4	-	F2	F2	F2	F3,4
	5	F3,4;D3	-	F2;Q2[b]	F2;D2[c]	F2	F3,4
	6	F3,4	F2;D2[c]	F2[c]	F2	F2;D2[c]	-

[a] VO = Volatile Organics
RP = Respirable Particulates
PP = Pesticides/PCBs
FM = Formaldehyde
MN = Elements
AE = Air Exchange
F = field sample collection
D = collection of D-duplicate for analysis at RTI
Q = collection of Q-duplication for analysis at external laboratory

[b] Expose QC set for RTI

[c] Expose QC set for QA lab

TABLE 118. OFFICE BUILDING TRIP 1 - SAMPLE INVENTORY AUDIT

MEMORANDUM

To: Dr. Handy

From: Karen Brady

Date: August 19, 1983

Subject: Office Building 1 - Sample Inventory Audit

Adherence to Sampling Schedule

Sample Type	Comment
VO-F	Schedule followed
VO-D	Schedule followed
VO-Q	Day 1 Q2 collected at Location 2 instead of 6
VO-FC/FB	Set No. 1 designated for RTI instead of QA Lab Set No. 3 designated for RTI instead of QA Lab Set No. 4 designated for QA Lab instead of RTI Set No. 5 and 6 exposed but not scheduled
RP-F	No samples collected at location 2
RP-D	Day 1 - D1 collected at location 6 instead of 2 Day 2 - no samples collected
RP-Q	Day 1 - no samples collected Day 2 - Q3 collected at location 6 instead of 1
RP-FB	Day 1 - field blank for RTI exposed at location 6 instead of 2
PP-F	Schedule followed
PP-D	Day 1 - mislabeled as Q (location 1)
PP-Q	Schedule followed except above
PP-FC/FB	Day 2 - QC set for QA lab collected at location 3 instead of 5
FM-F	Schedule followed
FM-D	Schedule followed
FM-Q	Schedule followed
FM-FC/FB	A fifth QC set exposed at location 5, not scheduled

(continued)

TABLE 118. (cont'd.)

Sample Type	Comment
MN-F	Schedule followed
MN-D	Schedule followed
MN-Q	Schedule followed
MN-FB	Day 2 - No blank exposed, two scheduled
AE-F	Day 1 - two sets of samples taken
AE-D	Day 2 - no duplicates taken at location 1
Sample Loss	
MN-115-6-F2	Not collected; pump failure
MN-116-4-D2	Not collected; pump failure
FM-112-3-F1	Not collected; pump failure

TABLE 119. OFFICE BUILDING TRIP 2 - SAMPLE INVENTORY AUDIT

MEMORANDUM

To: Dr. Handy

From: Karen Brady

Date: September 13, 1983

Subject: Office Building 2 - Sample Inventory Audit

Sample Type	Sample ID No.	Comment
VO	211-3 VO-F2	Equipment malfunction Sampling train disconnected
RP	216-2 RPF-F1	Not collected
	216-2 RPC-F1	Not collected
MN	212-1 MN-F1	Equipment found unplugged
	215-4 MN-Q1	Pump failure
	215-4 MN-F1	Pump failure
AE	215-4 AE-3F	Sampler did not work
	213-9 AE-4F	Battery not charged

TABLE 120. OFFICE BUILDING TRIP 3 - SAMPLE INVENTORY AUDIT

MEMORANDUM

To: Dr. Handy

From: Karen Brady

Date: January 4, 1984

Subject: Office Building 3 - Sample Inventory Audit

Sample Type	Sample ID No.	Comment
RP	312-9 RF-F1 312-9 RC-F1	Power connection broken
	316-0 RF-D2 316-0 RC-D2	No pump
	031-5 RP-FB-04 for RTI at Loc.6, Day 2	Not made
FM	312-9 FM-D1	F1 sample was collected but mislabeled. The duplicate will be analyzed in its place. Another duplicate collected on Day 2.
	313-7 FM-Q1	F1 sample was collected but mislabeled. The Q sample will be analyzed in its place. Another Q sample was collected on Day 2.
	314-5 FM-F2	Pump failure
MN	311-1 MN-F1	Pump failure
	316-0 MN-D2	Pump failure due to cold weather
	031-5 MN-FB-04 Loc. 6 Day 2	Not made
AE	311-1 AE-4D	Sampler off
	313-7 AE-3F	Sampler did not activate
	315-2 AE-2F	Sampler did not activate

TABLE 121. OFFICE BUILDING - COMPLETENESS OF SAMPLE COLLECTION AND ANALYSIS

Field Samples	Samples Scheduled/Analyzed[a]					
	VO	RP	PP	FM	MN	AE
Office Building 1	24/24	8/6	12/12	12/0	12/11	16/12
Office Building 2	24/22	8/[b]	12/12	12/12	12/10	16/14
Office Building 3	24/24	8/7	12/11	12/12	12/11	16/14
Total	72/70	24/13	36/35	36/24	36/32	48/40
% Completion	97	54	97	67	89	83
D-Duplicates						
Office Building 1	3/3	1/1	2/3	2/0	2/1	2/0
Office Building 2	3/3	1/0	2/2	2/2	2/2	2/2
Office Building 3	3/2	1/0	2/2	2/2	2/1	2/2
Total	9/8	3/1	6/6	6/4	6/4	6/4
% Completion	89	33	100	67	67	67
Q-Duplicates						
Office Building 1	3/3	0/0	2/0	2/2	2/2	0/0
Office Building 2	3/3	0/0	2/0	2/0	2/1	0/0
Office Building 3	3/3	0/0	2/0	2/0	2/1	0/0
Total	9/9	0/0	6/0	6/2	6/4	0/0
% Completion	100	-	-	33	67	-

[a] VO = Volatile Organics
RP = Respirable Particulates
PP = Pesticide/PCBs
FM = Formaldehyde
MN = Elements
AE = Air Exchange

[b] Samples lost during analysis.

TABLE 122. OFFICE BUILDING TRIP 1 - VOLATILE ORGANICS QC SAMPLES

Target Compound	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
	N	Mean	% RSD	N	Mean	% RSD
Chloroform	3	122	3	3	4	25
1,2-Dichloroethane	3	154	3	3	ND[b]	-
1,1,1-Trichloroethane	3	180	4	3	9	22
Benzene	3	245	3	3	58	38
Carbon tetrachloride	3	194	1	3	ND	-
Trichloroethylene	3	219	3	3	4	50
Tetrachloroethylene	3	45	13	3	ND	-
Chlorobenzene	3	108	3	3	1	100
Styrene	2	113	-	3	8	138
m,*p*-Dichlorobenzene	2	108	-	3	2	0
o-Dichlorobenzene	2	107	-	3	ND	-
Ethylbenzene	2	119	-	3	3	67
o-Xylene	2	113	-	3	1	100
m,*p*-Xylene	2	118	-	3	4	25
1,1,2,2-Tetrachloroethane	2	113	-	3	ND	-
n-Decane	-	NA[c]	-	3	ND	-
n-Undecane	-	NA	-	3	8	62
n-Dodecane	-	NA	-	3	4	75

[a] Corrected for background

[b] ND = not detected

[c] NA = not analyzed

The second office building trip (Table 123) gave more acceptable field control results. Benzene (67%) and 1,1,2,2-tetrachloroethane (72%) gave low recoveries; ethylbenzene (133%) and trichloroethylene (126%) gave high recoveries. Only benzene (48 ng/cartridge) and styrene (14 ng/cartridge) had notable background levels on field blanks.

The field control results from the third trip gave acceptable recovery data (Table 124). All but two of the targets showed 86 to 111% recoveries; 1,2-dichloroethane (122%) and n-decane (124%) had recoveries outside this range. Background levels of chloroform (35 ng/cartridge) and benzene (23 ng/cartridge) were noted in the field blanks.

Pesticide-PCBs/Formaldehyde--

The field controls from all three office building sampling trips showed the same pattern: a wide range of pesticide recoveries with chlordane and α-BHC exhibiting very low values and p,p'-DDD giving excessively high returns (Tables 125 to 127). Formaldehyde recoveries were 93% and 78% for the second and third trip, respectively. All formaldehyde samples from the first trip were incorrectly analyzed so no data are available.

Duplicate Sample Analysis

Volatile Organics--

In an effort to assess method precision, 25% of all field samples were collected in duplicate. Both samples from one-half of the duplicate pairs were analyzed at RTI and were designated as D-duplicates. One sample from each of the other duplicate pairs was sent to an external laboratory for analysis and was identified as Q-duplicate. The following discussion is based on the arbitrary criterion that a percent relative standard deviation (% RSD) of less than 35% is acceptable.

During the first sampling trip, three volatile organic samples were collected in duplicate. These samples were analyzed and the agreement between analyte concentration calculated and summarized (Table 128). In one sample set, benzene (50% RSD) and 1,1,1-trichloroethane (52% RSD) were the only target compounds which exhibited poor precision. In another sample pair, the concentration of the same compounds plus chloroform (53% RSD) gave the worst agreement. In the third duplicate pair, the concentrations of styrene, ethylbenzene, and o-xylene possessed the highest between-sample variability.

TABLE 123. OFFICE BUILDING TRIP 2 - VOLATILE ORGANICS QC SAMPLES

	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
Target Compound	N	Mean	% RSD	N	Mean	% RSD
Chloroform	3	89	3	2	4	-
1,2-Dichloroethane	3	98	5	2	ND[b]	-
1,1,1-Trichloroethane	3	92	4	2	1	-
Benzene	3	67	6	2	48	-
Carbon tetrachloride	3	108	8	2	ND	-
Trichloroethylene	3	126	39	2	2	-
Tetrachloroethylene	3	102	41	2	ND	-
Chlorobenzene	3	93	63	2	1	-
Styrene	2	112	-	2	14	-
m,*p*-Dichlorobenzene	2	109	-	2	ND	-
o-Dichlorobenzene	2	108	-	2	ND	-
Ethylbenzene	2	133	-	2	3	-
o-Xylene	2	112	-	2	1	-
m,*p*-Xylene	2	118	-	2	3	-
1,1,2,2-Tetrachloroethane	3	72	38	2	ND	-
n-Decane	-	NA[c]	-	2	ND	-
n-Undecane	-	NA	-	2	3	-
n-Dodecane	-	NA	-	2	2	-

---

[a] Corrected for background.

[b] ND = Not Detected

[c] NA = Not Analyzed

TABLE 124. OFFICE BUILDING TRIP 3 - VOLATILE ORGANICS QC SAMPLES

	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
Target Compound	N	Mean	% RSD	N	Mean	% RSD
Chloroform	3	86	14	3	35	23
1,2-Dichloroethane	3	122	23	3	ND[b]	-
1,1,1-Trichloroethane	3	110	29	3	7	86
Benzene	3	101	9	3	23	52
Carbon tetrachloride	3	109	11	3	1	100
Trichloroethylene	3	111	7	3	2	100
Tetrachloroethylene	3	100	9	3	ND	-
Chlorobenzene	3	94	11	3	2	50
Styrene	3	107	8	3	2	50
m,*p*-Dichlorobenzene	3	109	12	3	ND	-
o-Dichlorobenzene	3	104	12	3	2	150
Ethylbenzene	3	104	9	3	1	100
o-Xylene	3	106	8	3	1	100
m,*p*-Xylene	3	107	8	3	3	67
1,1,2,2-Tetrachloroethane	3	94	16	3	ND	-
n-Decane	3	124	12	3	ND	-
n-Undecane	3	99	14	3	5	120
n-Dodecane	3	97	14	3	2	50

[a] Corrected for background

[b] ND = not detected

TABLE 125. OFFICE BUILDING TRIP 1 - PESTICIDE/FORMALDEHYDE QC SAMPLES

	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
Target Compound	N	Mean	% RSD	N	Mean	% RSD
α-BHC	3	34	18	3	1	71
HCB	3	64	67	3	ND[b]	-
β,γ-BHC	3	59	51	3	ND	-
Heptachlor	3	110	23	3	ND	-
Heptachlor Epoxide/ Oxychlordane	3	52	38	3	ND	-
p,p'-DDE	3	79	37	3	ND	-
p,p'-DDD	3	127	13	3	ND	-
p,p'-DDT	3	64	95	3	ND	-
Arochlor 1260	3	78	45	3	7.4	104
Chlordane	3	23	109	3	7.0	84
Target Compound						
Formaldehyde	SL[c]	-	-	SL[c]	-	-

[a] Corrected for background

[b] ND = not detected

[c] SL = samples lost

TABLE 126. OFFICE BUILDING TRIP 2 - PESTICIDE/FORMALDEHYDE QC SAMPLES

	Field Controls[a]			Field Blanks		
	% Recovery			Background, ng		
Target Compound	N	Mean	% RSD	N	Mean	% RSD
α-BHC	3	28	79	3	ND[b]	-
HCB	3	NC[c]	-	3	ND	-
β,γ-BHC	3	NC	-	3	ND	-
Heptachlor	3	NC	-	3	5.6	70
Heptachlor Epoxide/ Oxychlordane	3	57	44	3	ND	-
p,*p*'-DDE	2	113	-	3	ND	-
p,*p*'-DDD	3	194	36	3	ND	-
p,*p*'-DDT	3	116	4	3	8.7	126
Arochlor 1260	3	85	31	3	2.9	114
Chlordane	3	48	44	3	6.3	51
Target Compound						
Formaldehyde	2	93	1	2	2.5μg	-

[a] Corrected for background

[b] ND = not detected

[c] NC = not calculated; high interferences

TABLE 127. OFFICE BUILDING TRIP 3 - PESTICIDE/FORMALDEHYDE QC SAMPLES

	Field Controls[a]			Field Blanks		
	% Recovery			Background, ng		
Target Compound	N	Mean	% RSD	N	Mean	% RSD
α-BHC	3	65	20	3	ND[b]	-
HCB	3	90	38	3	ND	-
β,γ-BHC	3	95	19	3	ND	-
Heptachlor	3	94	19	3	4.0	100
Heptachlor Epoxide/ Oxychlordane	3	81	18	3	ND	-
p,*p*'-DDE	3	119	17	3	ND	-
p,*p*'-DDD	3	255	16	3	ND	-
p,*p*'-DDT	3	124	15	3	ND	-
Arochlor 1260	3	70	14	3	7.0	106
Chlordane	3	63	16	3	ND	-
Target Compound						
Formaldehyde	3	78	40	3	2.2μg	-

[a] Corrected for background

[b] ND = not detected

TABLE 128. OFFICE BUILDING TRIP 1 - VOLATILE ORGANIC DUPLICATES

		Conc., ng/L		
Sample ID	Target Compound	F4	D4	% RSD
1131-VO	Chloroform	0.74	0.77	2.8
	1,1,1-Trichloroethane	740	340	52
	Benzene	8.8	4.2	50
	Trichloroethylene	0.94	0.78	13
	Tetrachloroethylene	18	15	13
	Styrene	1.7	1.7	0.0
	m,p,-Dichlorobenzene	0.60	0.64	4.6
	Ethylbenzene	140	120	11
	o-Xylene	56	55	1.3
	m,p-Xylene	150	150	0.0
		F1	D1	
1149-VO	Chloroform	0.64	1.4	53
	1,1,1-Trichloroethane	180	330	42
	Benzene	0.63	1.6	62
	Styrene	11	17	30
	m,p-Dichlorobenzene	0.66	0.90	22
	Ethylbenzene	13	17	19
	o-Xylene	11	15	22
	m,p-Xylene	30	48	33
		F3	D3	
1156-VO	Chloroform	0.7	1.1	31
	1,1,1-Trichloroethane	140	130	8.6
	Benzene	2.4	2.5	2.9
	Trichloroethylene	1.2	1.1	6.1
	Tetrachloroethylene	2.3	2.0	9.9
	Styrene	15	3.8	84
	m,p,-Dichlorobenzene	1.6	1.4	9.4
	Ethylbenzene	60	13	91
	o-Xylene	58	28	49
	m,p-Xylene	99	93	4.4
	Decane	140	180	18.
	Undecane	85	100	11
	Dodecane	43	45	3.2

The three duplicate samples collected for volatile organic analysis during the second trip indicated that the precision estimate for benzene (69% RSD) and ethylbenzene (55% RSD) was high (Table 129). The precision for all measurable analytes in the second duplicate pair was less than 35% RSD. The final duplicate pair gave much poorer agreement: chloroform (41% RSD), 1,1,1-trichloroethane (52% RSD), benzene (106% RSD), tetrachloroethylene (61% RSD), and trichloroethylene (40% RSD).

During the third trip to the office building, only two volatile organic samples were collected for D-duplicates. One sample set showed only chloroform (59%) precision in excess of 35% (Table 130). The targets found in the other duplicate pair showed fair agreement: only carbon tetrachloride (15% RSD) and tetrachloroethylene (33% RSD) passed the "acceptability" test.

Pesticides/PCBs--

A total of 7 pesticide/PCB duplicates were collected during the three sampling trips to the office building (Tables 131 to 133). Four of these pairs contained both α-BHC (53-108% RSD) and heptachlor (30 -86% RSD). HCB (127% RSD), chlordane (65% RSD), and Arochlor 1260 (51% RSD) and p,p'-DDT (8.0%; 14% RSD) were also found.

Respirable Particulates--

One of the respirable particulate samples at the first Office Building was collected in duplicate. Measurement precision for both the fine (3.5% RSD) and coarse (6.5% RSD) fractions was excellent. Duplicates were not collected at the second or third Office Building sampling.

Elements--

The analytical results of the duplicate samples collected on Nucleopore are shown in Tables 134 through 137.

Performance Audit Samples

Volatile Organics--

Performance audit samples were prepared by fortifying Tenax cartridges with selected aromatic and aliphatic target compounds. RTI supplied the Tenax cartridge and EMSL/EPA at RTP prepared the audit samples by spiking the cartridges with known amounts of benzene, 1,2-dichloroethane, trichloroethylene, tetrachloroethylene, chlorobenzene, ethylbenzene, and chlorobenzene.

TABLE 129. OFFICE BUILDING TRIP 2 - VOLATILE ORGANIC DUPLICATES

		Conc., ng/L		
Sample ID	Target Compound	F4	D4	% RSD
2139-VO	Chloroform	2.3	2.4	3.0
	1,1,1-Trichloroethane	71	81	8.2
	Benzene	11	3.8	69
	Trichloroethylene	77	49	31
	Tetrachloroethylene	2.1	2.2	3.2
	Chlorobenzene	0.29	0.39	21
	Styrene	7.1	5.6	17
	m,*p*,-Dichlorobenzene	1.1	1.1	0.0
	Ethylbenzene	6.4	2.8	55
	o-Xylene	6.3	6.9	6.4
	m,*p*-Xylene	15	13	10
	Decane	40	40	0.0
	Undecane	45	45	0.0
	Dodecane	17	18	4.0
		F1	D1	
2147-VO	Chloroform	0.96	1.5	31
	1,1,1-Trichloroethane	32	50	31
	Benzene	6.4	5.8	7.0
	Carbon Tetrachloride	0.80	1.3	34
	Trichloroethylene	18	17	4.0
	Tetrachloroethylene	1.4	1.1	17
	Styrene	9.4	9.3	21
	m,*p*-Dichlorobenzene	0.93	1.0	5.1
	Ethylbenzene	7.9	7.5	3.7
	o-Xylene	8.9	9.3	3.1
	m,*p*-Xylene	21	21	0.0
	Decane	35	38	5.8
	Undecane	36	39	5.6
	Dodecane	18	19	3.8
		F3	D3	
2154-VO	Chloroform	1.5	0.82	41
	1,1,1-Trichloroethane	140	65	52
	Benzene	2.4	17	106
	Trichloroethylene	15	27	40
	Tetrachloroethylene	3.0	1.2	61
	Chlorobenzene	0.54	0.74	22
	m,*p*,-Dichlorobenzene	1.2	1.2	0.0
	Ethylbenzene	9.5	7.9	13
	o-Xylene	10	8.6	11
	m,*p*-Xylene	24	23	3.0

TABLE 130. OFFICE BUILDING TRIP 3 - VOLATILE ORGANIC DUPLICATES

Sample ID	Target Compound	Conc., ng/L F4	 D4	% RSD
3137-VO	Chloroform	9.0	3.7	59
	1,1,1-Trichloroethane	90	71	17
	Benzene	3.1	2.0	30
	Trichloroethylene	48	36	20
	Tetrachloroethylene	10	7.2	23
	Styrene	8.9	6.0	28
	m,p,-Dichlorobenzene	0.79	0.59	20
	Ethylbenzene	5.9	4.0	27
	o-Xylene	4.3	2.9	27
	m,p-Xylene	11	7.7	25
	Decane	5.8	4.0	26
	Undecane	11	8.0	22
	Dodecane	4.3	3.1	23
		F1	D1	
3145-VO	Chloroform	17	9.7	39
	1,1,1-Trichloroethane	12	24	47
	Benzene	1.2	2.0	35
	Carbon Tetrachloride	0.43	0.53	15
	Trichloroethylene	8.1	15	42
	Tetrachloroethylene	0.47	0.76	33
	Styrene	1.6	3.2	47
	Ethylbenzene	1.3	2.2	36
	o-Xylene	0.84	1.5	40
	m,p-Xylene	2.3	4.0	38
	Decane	1.0	2.2	53

TABLE 131. OFFICE BUILDING TRIP 1 - PESTICIDES/PCB DUPLICATES

Sample ID	Target Cmpd.	Conc., ng/L F1	 D1	% RSD
1115-PP	α-BHC	2.19	0.994	53
	Heptachlor	3.50	5.36	30
		F2	D2	
1131-PP	α-BHC	0.859	0.114	108
	HCB	0.220	4.12	127
	Heptachlor	3.30	0.803	86
		F1	D1	
1149-PP	None	-	-	-

TABLE 132. OFFICE BUILDING TRIP 2 - PESTICIDES/PCB DUPLICATES

Sample ID	Target Cmpd.	Conc., ng/L F2	 D2	% RSD
2139-PP	Chlordane	11.9	32.0	65
	Arochlor 1260	11.2	23.7	51
	Arochlor 1254	11.5	10.5	6.4
		F1	D1	
2147-PP	*p*,*p*'-DDT	1.21	1.08	8.0

TABLE 133. OFFICE BUILDING TRIP 3 - PESTICIDES/PCB DUPLICATES

		Conc., pg/L		
Sample ID	Target Cmpd.	F1	D1	% RSD
3145-PP	α-BHC	0.40	1.38	78
	Heptachlor	2.39	6.62	66
		F2	D2	
3137-PP	α-BHC	3.12	0.910	59
	Heptachlor	8.00	17.6	53
	p,*p*'-DDT	0.154	0.187	14

TABLE 134. OFFICE BUILDING TRIP 1 - ELEMENT SAMPLE DUPLICATE LOCATION NO. 4

Element	LOD(ng)	Reported Concentration (ng/m^3) F[a]	Reported Concentration (ng/m^3) D[b]	Element	LOD(ng)	Reported Concentration (ng/m^3) F	Reported Concentration (ng/m^3) D
Na	447	T[c]	T	Co	-	T	N[d]
Mg	818	T	T	Ni	34	N	T
Al	703	T	T	Cu	24	T	46
Si	342	1760	2440	Zn	18	73	40
P	81	N	N	As	61	N	N
S	688	1510	2150	Se	88	N	N
Cl	2058	N	N	Br	44	N	T
K	66	364	511	Rb	-	N	N
Ca	57	1750	2800	Sr	81	N	N
Sc	-	N	N	Zr	128	-	-
Ti	42	T	T	Mo	2408	-	-
V	37	N	N	Cd	201	N	N
Cr	790	N	N	Hg	94	N	N
Mn	25	N	N	Pb	93	N	N
Fe	149	365	578				

[a] F = Field Sample

[b] D = Duplicate Sample

[c] T = Trace quantity of element found

[d] N = Element not detected (less than LOD)

TABLE 135. OFFICE BUILDING TRIP 2 - ELEMENT SAMPLE DUPLICATE LOCATION NO. 4

		Reported Concentration (ng/m^3)				Reported Concentration (ng/m^3)	
Element	LOD(ng)	F[a]	D[b]	Element	LOD(ng)	F	D
Na	447	N[c]	N	Co	-	N	N
Mg	818	N	N	Ni	34	N	N
Al	703	N	N	Cu	24	N	N
Si	342	T[d]	T	Zn	18	N	T
P	81	N	N	As	61	N	N
S	688	N	N	Se	88	N	N
Cl	2058	N	N	Br	44	N	N
K	66	N	N	Rb	-	N	N
Ca	57	N	T	Sr	81	N	N
Sc	-	N	N	Zr	128	-	-
Ti	42	N	N	Mo	2408	-	-
V	37	N	N	Cd	201	N	N
Cr	790	N	N	Hg	94	N	N
Mn	25	N	N	Pb	93	N	N
Fe	149	N	N				

[a] F = Field Sample

[b] D = Duplicate Sample

[c] N = Element not detected (less than LOD)

[d] T = Trace quantity of element found

TABLE 136. OFFICE BUILDING TRIP 2 - ELEMENT SAMPLE DUPLICATE LOCATION NO. 6

Element	LOD(ng)	Reported Concentration (ng/m^3)		Element	LOD(ng)	Reported Concentration (ng/m^3)	
		F[a]	D[b]			F	D
Na	447	N[c]	T[d]	Co	-	N	N
Mg	818	N	N	Ni	34	N	N
Al	703	T	T	Cu	24	T	T
Si	342	1750	2140	Zn	18	T	T
P	81	N	N	As	61	N	N
S	688	4430	6400	Se	88	N	N
Cl	2058	N	N	Br	44	T	T
K	66	T	247	Rb	-	N	N
Ca	57	359	394	Sr	81	N	N
Sc	-	N	N	Zr	128	-	-
Ti	42	T	T	Mo	2408	-	-
V	37	N	N	Cd	201	-	-
Cr	790	N	N	Hg	94	N	N
Mn	25	N	N	Pb	93	T	T
Fe	149	T	540				

[a] F = Field Sample

[b] D = Duplicate Sample

[c] N = Element not detected (less than LOD)

[d] T = Trace quantity of element found

TABLE 137. OFFICE BUILDING TRIP 3 - ELEMENT SAMPLE DUPLICATE
LOCATION NO. 4

Element	LOD(ng)	Reported Concentration (ng/m^3) F[a]	D[b]	Element	LOD(ng)	Reported Concentration (ng/m^3) F	D
Na	447	N[c]	N	Co	-	-	-
Mg	818	N	N	Ni	34	N	N
Al	703	N	N	Cu	24	N	N
Si	342	N	N	Zn	18	N	N
P	81	N	N	As	61	N	N
S	688	N	T[d]	Se	88	N	N
Cl	2058	N	N	Br	44	N	T
K	66	T	N	Rb	-	-	-
Ca	57	T	T	Sr	81	N	N
Sc	-	-	-	Zr	128	N	N
Ti	42	N	N	Mo	2408	T	N
V	37	N	N	Cd	201	N	N
Cr	790	N	N	Hg	94	N	N
Mn	25	N	N	Pb	93	N	T
Fe	149	T	N				

[a] F = Field Sample

[b] D = Duplicate Sample

[c] N = Element not detected (less than LOD)

[d] T = Trace quantity of element found

The analysis of the audit samples were carried out blind; each cartridge was given a legitimate study number and chain-of-custody form before being introduced into the sample chain. The number of audit samples analyzed in this fashion amounted to approximately 15% of the total field and duplicate cartridges. The results were reported to EPA without any correction for background and are summarized in Tables 138 to 140.

The audit samples analyzed with the samples from the first office building trip indicated an overall negative analytical bias (Table 138). At the indicated spike level, the measurement of benzene, trichloroethylene, and o-xylene exhibited a high positive bias; the benzene bias (+119%, +52%) was the most pronounced. The other 4 targets gave a negative bias, tetrachloroethylene (-50%) being the most severe.

The audit samples analyzed in support of the analysis of samples from the second office building trip also indicated a predominance of negative bias (Table 139). Tetrachloroethylene (+78%; 7%) and low levels of o-xylene (+48%) and chlorobenzene (+39%) exhibited a positive bias. The remaining targets showed a negative bias (-4 to -45%).

The audit samples analyzed for the third office building trip showed a similar pattern (Table 140). Trichloroethylene (+6%), chlorobenzene (+26%) and low levels of o-xylene (+48%) showed a positive bias. The other targets exhibited a negative bias (-7 to -41%).

Precision estimates from the performance audit results are also shown in Tables 138 to 140. Ethylbenzene and 1,2-dichloroethane showed the poorest precision; benzene and trichloroethylene, the best.

EPA performance audit samples were also sent to the external laboratory for analysis. The reported results are presented in Table 141.

HOME FOR THE ELDERLY

Field Operations

Two different homes for the elderly were monitored during the course of this study. Both buildings were multi-story structures and located in the Washington, DC area. The first sampling trip was carried out during March 23 to 26, 1983, and the other facility was sampled between January 9 to 12, 1984. Before the start of each study, a sampling schedule was prepared and distributed to the sampling personnel. These schedules were essentially the same for both sites and one is shown in slightly modified format in

TABLE 138. OFFICE BUILDING TRIP 1 - PERFORMANCE AUDIT RESULTS, VOLATILE ORGANICS[a,b]

Target Compound	Amt Added, ng	N	Average Bias	% RSD
Benzene	128	2	+119%	36
	299	2	+52%	1.0
1,2-Dichloroethane	180	2	-33%	141
	601	2	-2%	3.0
Trichloroethylene	143	4	+77%	30
Tetrachloroethylene	316	4	-50%	29
Chlorobenzene	107	4	-31%	85
Ethylbenzene	295	4	-15%	84
o-Xylene	128	2	+54%	1.0
	599	2	+11%	37

[a] All samples analyzed between 8/11-12/83.

[b] One blank cartridge was included in the sample set:
Benzene, 14 ng; Chlorobenzene, 2 ng; Ethylbenzene, 2 ng; Trichloroethylene, 1 ng; o-Xylene, 1 ng.

TABLE 139. OFFICE BUILDING TRIP 2 - PERFORMANCE AUDIT RESULTS, VOLATILE ORGANICS[a,b]

Target Compound	Amt Added, ng	N	Average Bias	% RSD
Benzene	128	2	-28%	38
	598	2	-44%	27
1,2-Dichloroethane	180	2	+5%	7.9
	360	2	-4%	12
Trichloroethylene	143	2	-13%	11
	356	2	-15%	7.5
Tetrachloroethylene	158	2	+78%	54
	631	2	+7%	43
Chlorobenzene	107	2	+39%	13
	646	2	-21%	60
Ethylbenzene	295	3[c]	-45%	101
o-Xylene	128	2	+48%	13
	599	1[c]	-22%	-

[a] All samples analyzed between 9/23-27/83.

[b] One blank cartridge was included in the sample set:
Benzene, 54 ng; Chloroform, 3 ng; Chlorobenzene, 2 ng; Ethylbenzene, 2 ng.

[c] No data for one sample - computer software problem.

TABLE 140. OFFICE BUILDING TRIP 3/ELDERLY HOME 2 - PERFORMANCE AUDIT RESULTS, VOLATILE ORGANICS[a]

Target Compound	Amt Added, ng	N	Average Bias	% RSD
Benzene	128	3	0.0%	13
	299	2	-4.0%	25
1,2-Dichloroethane	180	3	-17%	8.1
	601	2	-7%	44
Trichloroethylene	143	5	+6%	32
Tetrachloroethylene	316	5	-24%	28
Chlorobenzene	107	5	+26%	40
Ethylbenzene	295	5	-11%	28
o-Xylene	128	2	+48%	40
	599	3	-41%	27

[a] All analyses were performed between 3/21-30/84.

TABLE 141. PERFORMANCE AUDIT RESULTS REPORTED BY THE EXTERNAL LABORATORY, VOLATILE ORGANICS

	Office Building Trip 1			Office Building Trip 2		
Target Compound	Spike Level, ng	Reported, ng	% Rec	Spike Level, ng	Reported, ng	% Rec
Benzene	299	280	94	128	118	92
	299	217	73	598	526	88
1,2-Dichloroethane	180	181	101	180	153	85
	601	533	89	180	121	67
Trichloroethylene	143	103	72	143	99	69
	143	162	113	143	138	96
Tetrachloroethylene	316	199	63	631	189	30
	316	212	67	631	261	41
Chlorobenzene	107	47	44	107	31	29
	107	72	67	646	311	48
Ethylbenzene	295	166	56	295	107	36
		198	67	295	181	61
o-Xylene	71	0[a]	0	599	216	36
	599	444	74	128	0[b]	0

[a] 133 ng reported as m,p-Xylene

[b] 71 ng reported as m,p-Xylene

Table 142. Adherence to this schedule and any resulting sample loss during the first sampling trip was determined by performing a sample inventory audit (Table 143). This information and the sample log data for the second trip were compiled and completeness data calculated for the different sample types (Table 144). Completeness is defined as the percentage of samples scheduled for collection which were actually collected, analyzed, and for which target compound levels appear in the computer file.

Sample Analysis

The quality control procedures implemented for the determination of each target compound are discussed in Section 6.

Field Quality Control Samples

Volatile Organics--

The field controls from the first elderly home-1 gave recoveries in the range 76% to 99% for all target compounds (Table 145). These data are associated with exceptionally low variability, 2% to 14% RSD. However, substantial amounts of benzene (42 ng/cartridge) and 1,1,1-trichloroethane (50 ng/cartridge) were found on the field blanks. The target recoveries found for the elderly home-2 study were shifted higher, 81% to 117% (Table 146). The precision of the individual measurements were estimated as 3% to 24% RSD. Styrene (131 ng/cartridge), benzene (31 ng/cartridge), and 1,1,1-trichloroethane (14 ng/cartridge) background levels were found.

Pesticides-PCBs/Formaldehyde--

The field controls from the two elderly home sampling trips showed a similar pattern: a wide range of pesticide recoveries with chlordane and α-BHC exhibiting very low values and p,p'-DDD giving relatively high recoveries (Tables 147, 148). Formaldehyde recoveries were 93% and 78% for the first and second trip, respectively.

Duplicate Sample Analysis

Volatile Organics--

Duplicate volatile organic samples were collected at the two elderly homes sites in an effort to assess method precision. The precision observed for the first duplicate pair at the first site was remarkably good (Table 149). Only n-dodecane (40% RSD) and styrene (94% RSD) were suspect. The duplicate pair collected immediately afterwards gave much poorer reproducibility. Only carbon tetrachloride (14% RSD), tetrachloroethylene

TABLE 142. SAMPLING SCHEDULE - HOME FOR THE ELDERLY[a]

		Analyte Type[b]				
	VO	RP	PP	FM	MN	AE
Day 1-Location 1	F1,2	F1	F1	F1;Q1[d]	F1	F1,2
2	F1,2[c]	F1;Q1[d]	F1	F1	F1	F1,2
3	F1,2	F1;D1[c]	F1	F1	F1	F1,2
4	F1,2;D1,2[c]	F1	F1	F1	F1	F1,2
5	F1,2	F1	F1[c]	F1;D1[c]	F1	-
6	F1,2	F1	F1	F1	F1;D1[c]	-
Day 2-Location 1	F3,4	F2[c]	F2;D2[c]	F2	F2	F3,4
2	F3,4	F2	F2	F2;Q2[d]	F2	F3,4
3	F3,4	F2	F2;Q2[d]	F2	F2;D2[c]	F3,4
4	F3,4	F2	F2	F2	F2;Q2[d]	-
5	F3,4;Q3,4[d]	F2	F2	F2	F2	-
6	F3,4[c]	F2	F2	F2;D2[c]	F2	F1,2;D1,2
Day 3-Location 1	F5,6;D5,6[c]	F3	F3	F3	F3	F5,6
2	F5,6	F3	F3;D3[c]	F3	F3	F5,6
3	F5,6;Q5,6[d]	F3	F3	F3[c]	F3	-
4	F5,6	F3;D3[c]	F3;Q3[d]	F3	F3	F3,4
5	F5,6	F3	F3	F3	F3;Q3[d]	-
6	F5,6	F3;Q3[d]	F3	F3	F3	F3,4

[a] The second site had only 5 sampling locations (4 locations for AE collections)

[b] VO = Volatile Organics
RP = Respirable Particulates
PP = Pesticdes/PCBs
FM = Formaldehyde
MN = Elements
AE = Air Exchange
F = Field sample Collection
D = Duplicate sample collection for analysis by RTI
Q = Duplicate sample collection for analysis by external laboratory

[c] Expose QC set for RTI

[d] Expose QC set for QA lab

TABLE 143. ELDERLY HOME-1 - SAMPLE INVENTORY AUDIT

MEMORANDUM

To: Dr. Handy

From: Pat Blau

Date: April 11, 1983

Subject: Home for the Elderly 1 - Sample Inventory Audit

Sample Loss

Sample ID No.	Reason for Loss
131-3 FM-F1	Pump failure
133-9 MN-Q1	Disconnected tube
133-9 NO-Q1	Not collected
133-9 AE-2D	Not enabled
134-7 AE-2F	Not enabled
135-4 AE-2F	Not enabled
135-4 AE-1F	Couldn't get into site room
131-3 CO-F1 thru 6	No functioning monitors
133-9 CO-F1 thru 6	No functioning monitors
136-2 CO-F1 thru 6	No functioning monitors

Other Information

One incorrect calculation for volume collected on Sierra Dichot. Corrected.

TABLE 144. ELDERLY HOMES 1 AND 2 - COMPLETENESS OF SAMPLE COLLECTIONS AND ANALYSIS

	Samples Scheduled/Analyzed[a]					
Field Samples	VO	RP	PP	FM	MN	AE
Elderly Home-1	36/36	36/36	18/18	18/17	18/16	24/17
Elderly Home-2	30/29	30/29	15/13	15/15	15/15	24/24
Total	66/65	66/65	33/31	33/32	33/31	48/41
% Completion	98	98	94	97	94	85
D-Duplicates						
Elderly Home-1	4/4		2/2	2/2	2/1	2/4
Elderly Home-2	3/2		2/2	2/2	2/1	2/2
Total	7/6		4/4	4/4	4/2	4/4
% Completion	86		100	100	50	100
Q-Duplicates						
Elderly Home-1	4/3		2/2	2/2	2/1	0/0
Elderly Home-2	4/3		2/2	2/0	2/1	0/0
Total	8/6		4/4	4/2	4/2	0/0
% Completion	75		100	50	50	-

[a] VO = Volatile Organics
RP = Respirable Particulates
PP = Pesticides/PCBs
FM = Formaldehyde
MN = Elements
AE = Air Exchange

TABLE 145. ELDERLY HOME-1 - VOLATILE ORGANICS QC SAMPLES

	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
Target Compound	N	Mean	% RSD	N	Mean	% RSD
Chloroform	3	77	6	3	2	50
1,2-Dichloroethane	3	80	5	3	ND[b]	-
1,1,1-Trichloroethane	3	99	14	3	50	42
Benzene	3	76	9	3	42	38
Carbon tetrachloride	3	79	4	3	ND	
Trichloroethylene	3	87	5	3	2	150
Tetrachloroethylene	3	91	6	3	ND	-
Chlorobenzene	3	93	4	3	1	100
Styrene	3	85	5	3	3	67
m,p-Dichlorobenzene	3	82	6	3	4	25
o-Dichlorobenzene	3	76	4	3	1	200
Ethylbenzene	3	87	3	3	1	0
o-Xylene	3	87	5	3	1	0
m,p-Xylene	3	89	8	3	2	50
1,1,2,2-Tetrachloroethane	3	82	2	3	3	233
n-Decane	-	NA[c]	-	3	6	33
n-Undecane	-	NA	-	3	3	33
n-Dodecane	-	NA	-	3	1	100

[a] Corrected for background

[b] ND = not detected

[c] NA = not analyzed

TABLE 146. ELDERLY HOME-2 - VOLATILE ORGANICS QC SAMPLES

Target Compound	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
	N	Mean	% RSD	N	Mean	% RSD
Chloroform	3	103	8	3	10	610
1,2-Dichloroethane	3	105	15	3	ND[b]	-
1,1,1-Trichloroethane	3	116	24	3	14	79
Benzene	3	81	22	3	31	42
Carbon tetrachloride	3	86	15	3	2	100
Trichloroethylene	3	82	22	3	3	67
Tetrachloroethylene	3	99	6	3	1	100
Chlorobenzene	3	96	8	3	2	0
Styrene	3	112	17	2	131	8
m,*p*-Dichlorobenzene	3	110	4	3	1	100
o-Dichlorobenzene	3	106	5	3	2	100
Ethylbenzene	3	104	6	3	10	30
o-Xylene	3	102	7	3	5	40
m,*p*-Xylene	3	102	7	3	9	44
1,1,2,2-Tetrachloroethane	3	104	3	3	ND	-
n-Decane	3	117	14	3	ND	-
n-Undecane	3	110	6	3	4	25
n-Dodecane	3	98	9	3	4	25

[a] Corrected for background

[b] ND = not detected

TABLE 147. ELDERLY HOME-1 - PESTICIDE/FORMALDEHYDE QC SAMPLES

	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
Target Compound	N	Mean	% RSD	N	Mean	% RSD
α-BHC	3	32	100	3	16	100
HCB	3	45	67	3	ND[b]	-
β,γ-BHC	3	42	44	3	ND	-
Heptachlor	3	72	65	3	1.4	86
Heptachlor Epoxide/ Oxychlordane	3	54	35	3	1.9	100
p,p'-DDE	3	65	28	3	1.0	100
p,p'-DDD	3	83	7	3	ND	-
p,p'-DDT	3	66	30	3	1.9	100
Arochlor 1260	3	14	36	3	14	100
Chlordane	3	9	27	3	1.2	0
Target Compound						
Formaldehyde	3	93	4	3	2.5μg	-

[a] Corrected for background

[b] ND = not detected

TABLE 148. ELDERLY HOME-2 - PESTICIDE/FORMALDEHYDE QC SAMPLES

	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
Target Compound	N	Mean	% RSD	N	Mean	% RSD
α-BHC	1	84	-	3	.94	100
HCB	1	95	-	3	ND[b]	-
β,γ-BHC	1	87	-	3	ND	-
Heptachlor	1	89	-	3	ND	-
Heptachlor Epoxide/ Oxychlordane	1	72	-	3	ND	-
p,p'-DDE	1	115	-	3	ND	-
p,p'-DDD	1	218	-	3	ND	-
p,p'-DDT	1	166	-	3	ND	-
Arochlor 1260	1	64	-	3	9.8	28
Chlordane	1	61	-	3	1.3	115
Target Compound						
Formaldehyde	4	78	18	4	9.4µg	-

[a] Corrected for background

[b] ND = not detected

TABLE 149. ELDERLY HOME-1 - VOLATILE ORGANIC DUPLICATES

		Conc., ng/L		
Sample ID	Target Compound	F5	D5	% RSD
1313-VO	Chloroform	0.71	0.54	19
	1,2-Dichloroethane	0.21	0.19	7.1
	1,1,1-Trichloroethane	12	9.3	18
	Benzene	7.2	6.3	9.4
	Carbon Tetrachloride	0.72	0.76	3.8
	Trichloroethylene	0.28	0.22	17
	Tetrachloroethylene	1.0	1.0	0.0
	Styrene	0.14	0.49	94
	m,p,-Dichlorobenzene	1.6	2.0	16
	Ethylbenzene	1.7	1.7	0.0
	o-Xylene	2.0	2.0	0.0
	m,p-Xylene	4.5	4.9	6.0
	Decane	3.0	3.6	13
	Undecane	2.5	3.0	13
	Dodecane	2.5	1.4	40
		F6	D6	
1313-VO	Chloroform	1.3	0.38	77
	1,1,1-Trichloroethane	23	4.2	98
	Benzene	16	4.5	79
	Carbon Tetrachloride	0.73	0.60	14
	Trichloroethylene	0.40	0.24	35
	Tetrachloroethylene	5.8	3.6	33
	Styrene	0.68	0.24	68
	m,p-Dichlorobenzene	3.1	0.79	84
	Ethylbenzene	2.5	1.4	40
	o-Xylene	2.5	1.6	31
	m,p-Xylene	6.1	3.7	35
	Decane	5.1	2.0	62
	Undecane	3.2	1.50	51
	Dodecane	1.2	0.59	48

(continued)

TABLE 149. (cont'd.)

Sample ID	Target Compound	Conc., ng/L F1	Conc., ng/L D1	% RSD
1347-VO	Chloroform	0.38	0.45	12
	1,1,1-Trichloroethane	7.1	8.8	15
	Benzene	2.8	3.3	12
	Carbon Tetrachloride	0.68	0.82	13
	Tetrachloroethylene	0.88	1.0	9.0
	Styrene	1.4	2.5	40
	m,p,-Dichlorobenzene	0.83	0.78	4.4
	Ethylbenzene	1.0	1.2	13
	o-Xylene	1.0	1.3	18
	m,p-Xylene	2.6	3.1	12
	Decane	1.9	2.2	10
	Undecane	1.8	2.1	11
	Dodecane	0.87	1.1	16
		F2	D2	
1347-VO	Chloroform	4.0	3.2	16
	1,1,1-Trichloroethane	51	4.5	118
	Benzene	30	4.5	104
	Carbon Tetrachloride	1.2	0.82	27
	Trichloroethylene	0.70	0.23	72
	Tetrachloroethylene	4.2	3.7	9.0
	Styrene	4.9	3.1	32
	m,p-Dichlorobenzene	6.3	0.61	117
	Ethylbenzene	5.0	3.3	29
	o-Xylene	6.1	3.5	38
	m,p-Xylene	14	8.6	34
	Decane	3.0	1.6	43
	Undecane	2.9	1.7	37
	Dodecane	3.3	1.7	45

(33% RSD), and o-xylene (31% RSD) showed % RSD values less than 35%. The second duplicate pair exhibited excellent precision (4.4% to 18% RSD). Only styrene (40% RSD) indicated agreement between duplicate pairs worse than 35% RSD. The other sample from this pair collected immediately afterwards gave much poorer reproducibility. Benzene (104% RSD), dichlorobenzenes (117% RSD), 1,1,1-trichloroethane (118% RSD), and trichloroethylene (72% RSD) were particularly significant results.

The two volatile organic duplicate collections at the elderly home-2 showed the same pattern (Table 150). Overall, the initial sample pair gave good precision, only 1,1,1-trichloroethane (40% RSD), chlorobenzene (42% RSD), and benzene (73% RSD) were suspect. The measurable target compounds of the second duplicate pair gave much poorer agreement. Only benzene (30% RSD), ethylbenzene (23% RSD), and m,p-xylene (34% RSD) were judged acceptable.

Pesticides/PCBs--

Two pesticide/PCB samples at both elderly homes were collected in duplicate. The duplicate pairs taken at the elderly home-1 showed that HCB (141% RSD), p,p'-DDT (54%; 114% RSD), and heptachlor epoxide (96% RSD) gave the poorest reproducibility (Table 151). Chlordane (5.0%; 7.1% RSD) exhibited excellent precision. The two duplicate pairs collected at the elderly home-2 gave entirely different results (Table 152). The first duplicate samples showed RSD values between 2.6% and 8.0% for the four measurable targets. The other pair exhibited RSD values of 47%, 3.8%, 53%, and 32% for the same four compounds.

Inhalable and Respirable Particulates--

Two respirable particulate field samples at the elderly home-1 were collected in duplicate. The first sample pair showed excellent precision for both the fine (4.2% RSD) and coarse (6.9% RSD) fractions. However, the agreement observed for the second duplicate pair gave % RSD values of 56% and 49% for the two fractions. One duplicate collection was taken at the elderly home-2 site. Precision estimates were calculated: fine (3.6% RSD) and coarse (11% RSD).

Elements--

The analytical results of the duplicate samples collected on Nucleopore are shown in Table 153.

TABLE 150. ELDERLY HOME-2 - VOLATILE ORGANIC DUPLICATES

Sample ID	Target Compound	Conc., ng/L		% RSD
		F5	D5	
2311-VO	Chloroform	1.4	0.99	24
	1,1,1-Trichloroethane	8.4	4.7	40
	Benzene	5.3	1.7	73
	Chlorobenzene	1.5	0.81	42
	Tetrachloroethylene	1.2	1.5	16
	m,p,-Dichlorobenzene	0.37	0.49	20
	Ethylbenzene	2.8	3.2	9.4
	o-Xylene	2.7	3.3	14
	m,p-Xylene	7.7	9.0	11
	Decane	1.9	2.4	16
	Undecane	1.9	2.4	16
	Dodecane	1.9	2.4	16
		F6	D6	
2311-VO	Chloroform	1.5	0.67	54
	1,1,1-Trichloroethane	7.8	3.3	57
	Benzene	11	7.1	30
	Carbon Tetrachloride	1.4	0.54	63
	Trichloroethylene	1.3	0.56	56
	Tetrachloroethylene	5.4	3.1	38
	m,p,-Dichlorobenzene	0.78	0.42	42
	Ethylbenzene	4.6	3.3	23
	o-Xylene	6.1	3.5	38
	m,p-Xylene	14	8.6	34
	Decane	3.0	1.6	43
	Undecane	2.9	1.7	37
	Dodecane	3.3	1.7	45

TABLE 151. ELDERLY HOME-1 - PESTICIDES/PCB DUPLICATES

Sample ID	Target Cmpd.	Conc., ng/L F2	 D2	%RSD
1313-PP	α-BHC	0.503	0.780	30
	HCB	728	1.68	141
	Heptachlor	0.390	0.112	78
	Heptachlor epoxide	0.745	3.89	96
	p,*p*'-DDT	0.375	3.17	114
	Chlordane	11.3	12.5	7.1
		F3	D3	
1321-PP	α-BHC	2.28	1.53	28
	β/γ-BHC	1.64	2.16	19
	Heptachlor	4.66	2.60	40
	p,*p*'-DDE	1.08	0.764	24
	p,*p*'-DDD	0.26	0.307	12
	p,*p*'-DDT	1.87	4.17	54
	Chlordane	117	109	5.0
	Arochlor 1260	330	216	30
	Arochlor 1254	412	296	23

TABLE 152. ELDERLY HOME-2 - PESTICIDES/PCB DUPLICATES

		Conc., ng/L		
Sample ID	Target Compd.	F2	D2	%RSD
2311-PP	α-BHC	1.05	1.09	2.6
	Heptachlor	3.15	3.53	8.0
	p,*p*'-DDE	1.23	1.57	3.0
	p,*p*'-DDT	0.553	0.507	6.1
		F3	D3	
2329-PP	α-BHC	0.259	0.515	47
	Heptachlor	7.35	6.97	3.8
	p,*p*'-DDE	39.9	18.1	53
	p,*p*'-DDT	3.99	2.52	32

TABLE 153. ELDERLY HOME-2 - ELEMENT SAMPLE DUPLICATES - LOCATION NO. 3

		Reported Concentration (ng/m^3)				Reported Concentration (ng/m^3)	
Element	LOD (ng)	F[a]	D[b]	Element	LOD (ng)	F	D
Na	447	T[c]	N[d]	Co	-	-	-
Mg	818	N	N	Ni	34	T	N
Al	703	T	N	Cu	24	T	T
Si	342	1440	N	Zn	18	74	T
P	81	N	N	As	61	N	N
S	688	2590	T	Se	88	N	N
Cl	2058	N	N	Br	44	T	T
K	66	272	T	Rb	-	-	-
Ca	57	753	158	Sr	81	N	N
Sc	-	-	-	Zr	128	N	N
Ti	42	T	N	Mo	2408	N	N
V	37	T	N	Cd	201	N	N
Cr	790	N	N	Hg	94	N	N
Mn	25	T	N	Pb	93	402	T
Fe	149	794	T				

[a] F = Field Sample

[b] D = Duplicate Sample

[c] T = Trace quantity of element found

[d] N = Element not detected (less than LOD)

Performance Audit Samples

Volatile Organics--

Five performance audit samples were analyzed with the samples collected at the elderly home-1 (Table 154). These materials consisted of a mixture of volatile organic target compounds spiked on Tenax by EPA and submitted blind to the RTI analyst. In general, a negative bias was observed for most of the seven target compounds (-8% to -49%). Only low levels of benzene (+25%), trichloroethylene (+7%), and tetrachloroethylene (+10%) showed a positive bias.

Since samples collected at the elderly home-2 were analyzed during the same periods as samples from the third office building sampling, the set of performance audit samples which were available at that time served as estimators of bias for each sample set. Once again, there was an overall negative bias (-7% to -41%). Only trichloroethylene (+6%), chlorobenzene (+26%), and low spike levels of o-xylene (+48%) showed a positive bias.

EPA performance audit samples were also sent to the external laboratory for analysis. The reported results are presented in Table 155.

SCHOOL

Field Operations

A multi-story public school building located in the Washington, DC area was monitored during the period May 23 to 26, 1983. Before the study was started, a sampling schedule was prepared and distributed to the sampling personnel. This schedule is shown in slightly different format in Table 156. Adherence to this schedule and any resulting sample loss were determined by performing a sample inventory audit (Table 157). This information was compiled and completeness data calculated for the different sample types (Table 158). Completeness is defined as the percentage of samples scheduled for collection which were actually collected, analyzed, and for which target compound levels appear in the computer file.

Sample Analysis

The quality control procedures implemented for the determination of each target compound are discussed in Section 6.

TABLE 154. ELDERLY HOME-1 - PERFORMANCE AUDIT RESULTS, VOLATILE ORGANICS

Target Compound	Amt Added, ng	N	Average Bias	%RSD
Benzene	128	2	+25%	19
	299	3	-13%	11
1,2-Dichloroethane	360	3	-8%	6.9
	601	2	-8%	18
Trichloroethylene	143	3	+7%	10
	712	2	-12%	19
Tetrachloroethylene	158	3	+10%	28
	316	2	+1%	18
Chlorobenzene	323	3	-42%	29
	646	2	-36%	12
Ethylbenzene	126	2	-12%	18
	590	3	-49%	14
o-Xylene	300	2	-15%	18
	599	3	-48%	11

All samples analyzed on 4/21/83.

TABLE 155. PERFORMANCE AUDIT RESULTS REPORTED BY THE EXTERNAL LABORATORY, VOLATILE ORGANICS

	Elderly Home-1		
Target Compound	Spike Level, ng	Reported, ng	% Recovery
Benzene	128	89	70
	299	162	54
1,2-Dichloroethane	601	629;428	88
	143	84	59
Trichloroethylene	712	461	65
Tetrachloroethylene	158	154	98
	316	244	77
Chlorobenzene	323	168	52
	646	431	67
Ethylbenzene	126	63	50
	590	304	52
o-Xylene	300	184;300	81

TABLE 156. SAMPLING SCHEDULE - SCHOOL

		Analyte Type[a]				
		VO	PP	FM	MN	AE
Day 1-Location	1	F1,2;D1	F1	F1;Q1[c]	F1[c]	F1,2
	2	F1,2[b]	F1	F1	F1;D1	F1,2
	3	F1,2	F1	F1;D1	F1;Q1	F1,2
	4	F1,2;Q1[b]	F1	F1[b]	F1	-
Day 2-Location	1	F3,4[c]	F2;D2	F2	F2	F3,4
	2	F3,4;D4	F2	F2;Q2[c]	F2;D2	F3,4
	3	F3,4;Q4	F2;Q2[c]	F2	F2;Q2[c]	D3,4
	4	F3,4[b]	F2	F2;D2	F2[b]	-
Day 3-Location	1	F5,6[b]	F3	F3	F3	F5,6
	2	F5,6;Q5	F3;D3[b]	F3	F3,D3[b]	F5,6
	3	F5,6;D5[c]	F3	F3[b]	F3;Q3	F5,6
	4	F5,6	F3;Q3[c]	F3	F3	-

[a] VO = Volatile Organics
PP = Pesticides/PCBs
FM = Formaldehyde
MN = Elements
AE = Air Exchange
F = Field sample collection
D = Duplicate sample collection for analysis at RTI
Q = Duplicate sample collection for analysis at the external laboratory

[b] Expose QC set for RTI

[c] Expose QC set for QA lab

TABLE 157. SCHOOL - SAMPLE INVENTORY AUDIT

MEMORANDUM

To: Dr. Handy

From: Pat Blau

Date: June 1, 1983

Subject: School - Sample Inventory Audit

Sample Loss

Sample Code: INAIR 123-0 VO-F4 lost because sampling train disconnected from pump.

Other Comments

1. Two filters for PIXIE analysis (one nucleopore and one mylar) were mislabeled and had to be corrected by one of the sampling team members.

2. One 2500 pump stopped during collection of formaldehyde sample. That sample collection (duplicate) was rescheduled.

TABLE 158. SCHOOL - COMPLETENESS OF SAMPLE COLLECTION AND ANALYSIS

Sample Type	Samples Scheduled/Analyzed					
	VO	RP	PP	FM	MN	AE
Field Samples	24/23	0/0	12/11	12/12	12/8	18/17
D-Duplicates	3/3	0/0	2/2	2/2	2/1	2/2
Q-Duplicates	3/2	0/0	2/2	2/2	3/1	0/0
Total	30/28	0/0	16/15	16/16	15/10	20/19
% Completeness	93.3	-	93.8	100	66.7	95.7

Field Quality Control Samples

Volatile Organics--

The field controls from the school sampling showed a relatively wide range of recoveries (Table 159). Most of the target compounds had recoveries in the range 79% to 105%. Higher recoveries were noted for *m*,*p*-dichlorobenzene (114%), chlorobenzene (120%), and ethylbenzene (121%); a low recovery was observed for trichloroethylene (64%). A fair amount of variability was evident in these data. Only 1,1,1-trichloroethane (17 ng/cartridge) and benzene (21 ng/cartridge) exhibited significant background levels on the field blanks.

Pesticide-PCBs/Formaldehyde--

The field controls from the school site showed a pattern which existed for the other sampling locations: chlordane (47%) and α-BHC (60%) gave low recoveries and *p*,p'-DDD (126%) possessed a relatively high recovery (Table 160).

Formaldehyde recovery was shown to be 60%.

Duplicate Sample Analysis

Volatile Organics--

Three volatile organic samples at the school site were collected in duplicate for analysis at RTI (Table 161). This corresponded to 12.5% of the total field samples collected. The first pair showed poor precision for the aromatics targets: benzene (40% RSD), styrene (78% RSD). The second duplicate pair showed basically the same pattern: a relative lack of agreement in the determination of aromatic target compounds. However, a trend of excessive variability was observed for the alkanes *n*-decane, *n*-undecane, and *n*-dodecane. The third sample pair exhibited the best precision; only chloroform (50% RSD) and the xylenes (44%; 64% RSD) had RSDs in excess of 35%.

Pesticide/PCBs--

Two pesticide/PCB field samples were collected in duplicate and analyzed at RTI (Table 162). For measurable targets in both duplicate pairs, precision estimates were poor: *p*,*p*'-DDT (51% RSD), HCB (70% RSD), and chlordane (47% RSD). Only *p*,*p*'-DDE (1.8% RSD) in the second sample pair exhibited good agreement.

TABLE 159. SCHOOL - VOLATILE ORGANICS QC SAMPLES

	Field Controls[a]			Field Blanks		
		% Recovery			Background, ng	
Target Compound	N	Mean	% RSD	N	Mean	% RSD
Chloroform	3	105	13	3	6	83
1,2-Dichloroethane	3	99	16	3	ND[b]	-
1,1,1-Trichloroethane	3	98	29	3	17	29
Benzene	3	79	42	3	21	57
Carbon tetrachloride	3	79	29	3	ND	-
Trichloroethylene	3	64	14	3	1	100
Tetrachloroethylene	3	89	21	3	ND	-
Chlorobenzene	3	120	50	3	1	100
Styrene	3	87	59	3	1	100
m,*p*-Dichlorobenzene	3	114	7	3	4	50
o-Dichlorobenzene	3	86	16	3	1	100
Ethylbenzene	3	121	58	3	1	100
o-Xylene	3	87	54	3	1	100
m,*p*-Xylene	3	100	43	3	4	25
1,1,2,2-Tetrachloroethane	3	92	35	3	ND	-
n-Decane	-	NA[c]	-	3	ND	-
n-Undecane	-	NA	-	3	14	100
n-Dodecane	-	NA	-	3	1	100

[a] Corrected for background

[b] ND = not detected

[c] NA = not analyzed

TABLE 160. SCHOOL - PESTICIDE/FORMALDEHYDE QC SAMPLES

Target Compound	Field Controls[a] N	Field Controls[a] % Recovery Mean	Field Controls[a] % RSD	Field Blanks N	Field Blanks Background, ng Mean	Field Blanks % RSD
α-BHC	3	66	97	3	ND[b]	-
HCB	3	51	67	3	3.1	100
β,γ-BHC	3	75	120	3	ND	-
Heptachlor	3	86	100	3	ND	-
Heptachlor Epoxide/ Oxychlordane	3	75	72	3	1.7	100
p,*p*'-DDE	3	70	71	3	ND	-
p,*p*'-DDD	3	126	86	3	ND	-
p,*p*'-DDT	3	26	77	3	7.1	116
Arochlor 1260	3	72	19	3	12	117
Chlordane	3	47	53	3	3.4	77
Target Compound						
Formaldehyde	3	60	5	3	5.7μg	-

[a] Corrected for background

[b] ND = not detected

TABLE 161. SCHOOL - VOLATILE ORGANIC DUPLICATES

		Conc., ng/L		
Sample ID	Target Compound	F1	D1	% RSD
1214-VO	1,1,1-Trichloroethane	6.0	6.6	6.7
	Benzene	7.3	13	40
	Carbon Tetrachloride	0.59	0.78	20
	Trichloroethylene	0.40	0.48	13
	Tetrachloroethylene	2.5	2.2	9.0
	Styrene	3.8	1.1	78
	m,*p*,-Dichlorobenzene	1.9	0.89	51
	Ethylbenzene	2.3	3.3	25
	o-Xylene	8.4	2.7	73
	m,*p*-Xylene	20	8.0	61
	Decane	0.76	0.88	10
	Undecane	0.85	0.84	0.8
	Dodecane	0.64	0.84	16
		F4	D4	
1222-VO	1,1,1-Trichloroethane	11	12	6.1
	Benzene	9.0	9.4	3.1
	Carbon Tetrachloride	0.65	1.1	36
	Trichloroethylene	0.57	0.60	3.6
	Tetrachloroethylene	1.5	5.4	80
	Styrene	2.0	4.5	54
	m,*p*-Dichlorobenzene	3.3	7.6	56
	Ethylbenzene	4.6	7.3	32
	o-Xylene	0.19	16	138
	m,*p*-Xylene	15	35	57
	Decane	0.28	1.5	97
	Undecane	0.53	1.4	64
	Dodecane	0.57	0.98	37

(continued)

TABLE 161. (cont'd.)

Sample ID	Target Compound	Conc., ng/L F5	Conc., ng/L D5	% RSD
1230-VO	Chloroform	0.73	0.35	50
	1,1,1-Trichloroethane	50	60	13
	Benzene	6.9	7.2	3.0
	Trichloroethylene	0.69	0.75	5.9
	Tetrachloroethylene	2.6	2.7	2.7
	Chlorobenzene	0.18	0.17	4.0
	Styrene	0.56	0.80	25
	m,p-Dichlorobenzene	1.8	2.2	14
	Ethylbenzene	1.7	1.5	8.8
	o-Xylene	1.8	4.8	64
	m,p-Xylene	4.2	2.2	44
	Decane	1.1	1.3	12
	Undecane	0.84	0.96	9.4
	Dodecane	0.84	0.78	5.2

TABLE 162. SCHOOL - PESTICIDES/PCB DUPLICATES

Sample ID	Target Cmpd.	Conc., pg/L F2	Conc., pg/L D2	% RSD
1214-PP	*p*,*p*'-DDT	41.2	19.2	51
		F3	D3	
1222-PP	HCB	8.3	2.8	70
	p,*p*'-DDE	0.38	0.39	1.8
	Chlordane	6.8	13.5	47

Performance Audit Samples

Volatile Organics--

Five performance audit samples were analyzed with the samples collected at the school site (Table 163). These materials consisted of a mixture of volatile organic target compounds spiked on Tenax by EPA and submitted blind to the RTI analyst. In general, a positive bias was observed for nearly all of the seven target compounds (+12% to +321%). Only trichloroethylene (-4%), tetrachloroethylene (-4%), and the low spike level of benzene (-9%) showed a negative bias. As indicated from the evaluation of duplicate sample analysis, the % RSD values for the audit compounds analytical precision was worst for the aromatics.

EPA performance audit samples were also sent to the external laboratory for analysis. The reported results are presented in Table 164.

TABLE 163. SCHOOL - PERFORMANCE AUDIT RESULTS, VOLATILE ORGANICS

Target Compound	Amt Added, ng	N	Average Bias	% RSD
Benzene	299	3	-9%	16
	598	2	+22%	40
1,2-Dichloroethane	360	5	+12%	10
Trichloroethylene	356	5	-4%	22
Tetrachloroethylene	631	5	-4%	15
Chlorobenzene	107	2	+321%	102
	323	3	+55%	78
Ethylbenzene	126	2	+185%	110
	590	3	+59%	48
o-Xylene	300	3	+48%	15
	599	2	+43%	101

All samples analyzed on 6/22/83.

TABLE 164. SCHOOL - PERFORMANCE AUDIT RESULTS REPORTED BY THE EXTERNAL LABORATORY, VOLATILE ORGANICS

Target Compound	Spike Level, ng	Reported, ng	% Recovery
Benzene	299	245	82
	598	696	116
1,2-Dichloroethane	360	237;340	80
Trichloroethylene	356	241;254	70
Tetrachloroethylene	631	400;429	66
Chlorobenzene	323	133;287	65
Ethylbenzene	126	54	43
	590	411	70
o-Xylene	300	190	63

REFERENCES

1. Sparacino, C. M., Blau, P., Sheldon, L. S. and E. D. Pellizzari, "Indoor Air Quality Monitoring Program, Part II: Analytical Protocols" Draft Work Plan, EPA Contract No. 68-02-3679. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC, 1983.
2. Pellizzari, E. D., Development of Method for Carcinogenic Vapor Analysis in Ambient Atmospheres. Publication No. EPA-650/2-74-121, Contract No. 68-02-1228, 148 pp., July, 1974.
3. Pellizzari, E. D., "Development of Analytical Techniques for Measuring Ambient Atmospheric Carcinogenic Vapors", Publication No. EPA- 600/2-75-075, Contract No. 68-02-1228, 187 pp., November, 1975.
4. Pellizzari, E. D., J. E. Bunch, B. H. Carpenter and E. Sawicki, Environ. Sci. Technol., 8, 552 (1975).
5. Pellizzari, E. D., "The Measurement of Carcinogenic Vapors in Ambient Atmospheres", Publication No. EPA-600-7-77-055, Contract No. 68-02-1228, 288 pp., June, 1977.
6. Pellizzari, E. D., "Evaluation of the Basic GC/MS Computer Analysis Technique for Pollutant Analysis", Final Report, EPA Contract No. 68-02-2998.
7. Pellizzari, E. D. and L. W. Little, "Collection and Analysis of Purgeable Organics Emitted from Treatment Plants", Final Report, EPA Contract No. 68-03-2681, 216 pp.
8. Webb, R. G. and A. C. McCall, J. Chromatogr. Science, 11, 366 (1973).

INDOOR AIR QUALITY IN FOUR BUILDINGS

APPENDICES A-F

by

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RTI Study #2190-38 Form #1

TEAM Indoor Air Study

GENERAL AREA DESCRIPTION

March 1983

RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

PURPOSE

The purpose of this form is to collect initial data in each area where monitoring is being conducted. The form should be completed, prior to, or at latest, during the initiation of the first monitoring period. This form is completed only one time for a particular area, but should be available to annotate any observed changes, during return visits to the area. A return visit is a visit during a different season of the year, not a return within a single three-day monitoring period.

DATE COMPETED: _____/_____/_____

A. BUILDING LOCATION

1. What is the exact location of this building? Provide the address and/or other specific locating information. Indicate on sketch (Figure 1.1) and city map. Use red "X" for this building.

____

____

____

2. Describe geographic characteristics of the immediate (½ mile radius) neighborhood. Include such information as:

   a. Percent open land--parks, etc. . . . . _________ %

   b. Is there a stream located in the area? . . . . . ☐ Yes . . ☐ No

   c. Is the area hilly? . . . . ☐ Yes . . ☐ No

   d. Are there tall structures which affect wind flow? . . . . ☐ Yes . . ☐ No

   e. Are there any condemned or demolished structures in the area? . . . . ☐ Yes . . ☐ No

Figure 1.1

Area Sketch

INDICATE
PREVAILING
WIND

INDICATE
NORTH

N.B. Use an "X" to represent site.
Use arabic numerals to indicate adjoining plots.
Use letters to represent point sources.

3. Describe each of the neighboring buildings or open areas. Account for all surrounding and/or adjoining structures or areas. Indicate location of each on sketch (Figure 1.1) using arabic numerals corresponding to table. Provide the following information:

Relative Location	Type of Structure/Open Area	If Structure, Approx. Age	Any Known or Observed Chemical Sources
1			
2			
3			
4			
5			
6			
7			
8			

4. Describe any potential point source for the chemicals or pollutants of interest within an area described as follows. Establish a one-half mile radius circle centered on the monitored structure. Extend the area an additional half mile upwind, creating an oval shaped area. Indicate location of each on the area sketch (Figure 1.1), using letters corresponding to the entry in the table (Figure 1.2).

Potential Point Sources

Letter	Relative Location	Distance	Type of Chemical	Other Comments
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				

5. a. Are there any major freeways (interstates, etc.) within the area as created in Section 4? Is yes, continue. If no, go to 5.d.

b. Draw freeway on sketch.

c. Indicate average traffic levels during:

(1) Rush hours . . . . . . ________ vehicles/hour

(2) Other times . . . . . ________ vehicles/hour

d. Indicate any major city streets in area on sketch and describe traffic flows:

(1) Rush hours . . . . . . ________ vehicles/hour

(2) Other times . . . . . ________ vehicles/hour

e. If area is not located on major thoroughfare, indicate average traffic flow on nearest street:

________ vehicles/hour

6. Has there been any exterior pesticide application in or on any of the areas described in Question 3, during the last 30 days? If yes, complete table.

Site #	When Applied	What Applied*	Quantity Applied	How Applied*	By Whom

* Obtain formulation and applications directions if possible. Place additional information on back of page.

7. Describe prevailing winds by obtaining information to create a wind rose. If localized information is not available, describe usual wind direction and speed for monitoring period. Place wind rose on back of this page.

____

____

____

Form #2

RTI Study #2190-38

TEAM Indoor Air Study

BUILDING QUESTIONNAIRE

March 1983

RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

PURPOSE

This form is designed to collect information describing the site at which the monitoring occurs. This form should be completed at the beginning of each three-day monitoring period. Some information which will be collected may not vary among monitoring periods, while other information is subject to change.

At the beginning of subsequent monitoring seasons, check the information in Parts A and B. If there are no changes, check the appropriate box(es). If there are changes, enter information only for the change(s).

DATE COMPLETED: _____/_____/_____

SITE ADDRESS: ______________________________

____

A. GENERAL BUILDING CHARACTERISTICS

☐ Season 2 No Change

☐ Season 3 No Change

1. Describe the site in terms of usage and surroundings.

____

____

____

____

____

2. How old is the building? Include information on additions and major renovations.

____

____

____

____

____

3. a. What is the approximate square footage of the building?

☐ Less than 5,000

☐ 5,000 - 7,999

☐ 8,000 - 11,999

☐ 12,000 - 14,999

☐ 15,000 - 19,999

☐ 20,000 - 24,999

☐ 25,000 or over

b. What is the approximate ceiling height in the majority of the structure?

__________ feet

If any part of the structure has an unusual ceiling height, specify that height and the square footage of the area covered by that ceiling.

Ceiling height . . . . __________ feet

Area . . . . __________ square feet

4. How many floors are above the substructure (mechanical areas)?

__________ floors

5. What are the structural materials of the exterior of the building? If more than one, give percentage of each.

☐ Wood . . . . __________ %

☐ Brick . . . . __________ %

☐ Stone facing . . . . __________ %

☐ Poured concrete . . . . __________ %

☐ Stucco . . . . __________ %

☐ Steel . . . . __________ %

☐ Glass . . . . __________ %

☐ Other (Specify ______________________________) . __________ %

6. Does the building have an attached or enclosed garage?

☐ Attached
☐ Enclosed
☐ No Garage

7. a. What is the source of water for the structure?

☐ Public → GO TO b.
☐ Private well
☐ Other (Specify ______________________________)

b. What is the primary source of public supply?

____

____

B. INTERNAL CHARACTERISTICS

☐ Season 2 No Change
☐ Season 3 No Change

1. Describe internal construction characteristics of the building.

a. Are there:

(1) false walls? . . . . ☐ Yes . . ☐ No

(2) movable walls? . . . . ☐ Yes . . ☐ No

(3) movable partitions? . . . . ☐ Yes . . ☐ No

(4) false ceilings? . . . . . . ☐ Yes . . ☐ No

(5) inter-floor spacing? . . . . ☐ Yes . . ☐ No

b. What are the surface materials of: (Indicate approximate surface area of each.)

(1) the walls? ______________________________

(2) the floors? ______________________________

(3) the ceilings? ______________________________

(4) any non-fixed structure? ______________________________

2. a. What is the main type of heating?

____

b. What are the secondary sources of heating?

____

c. What is the main type of heating fuel?

____

d. What type fuel is used for cooking in the main kitchen facility?

____

3. What is the source of hot water for the site? (Specify energy source.)

____

4. What type of air conditioning system(s) is(are) present? (Describe size, location, energy source, presence of filters and other characteristics.)

____

____

5. a. Are there any fixed ventilation systems, other than the heating and air conditioning, present in this structure?

☐ Yes ☐ No

↓

Specify type, location, control mechanism, filters, and particle scavengers:

____

____

____

b. Describe all secondary ventilation devices, including portable fans, and kitchen and bathroom exhausts.

____

____

____

____

6. Describe opening in walls and ceilings.

a. How many windows are present?

__________ windows

b. What percent can be opened?

__________ %

c. Describe any windows of unusual type or contruction.

____

____

____

____

d. How many door and other penetrations of walls are present?

__________ doors

__________ other penetrations

e. How many penetrations through the ceilings and floors are present? (Describe types and number.)

____

____

____

____

7. If known, what is the general rate of air exchange for this building?

__________ ach.

8. What are the normal temperature and relative humidity settings for the common areas of this building?

	Winter		Summer	
	Day	Night	Day	Night
a. Temperature	_____	_____	_____	_____
b. Relative humidity	_____	_____	_____	_____

9. Describe any other types of filtration or air cleaning mechanisms which affect this building.

____

____

____

____

10. What are the "R" values for insulation in:

a. exterior walls? . . . . __________

b. ceilings? . . . . __________

c. basement or other subflooring? . . . __________

d. other sites . . . . __________

C. BUILDING MODIFICATIONS

1. Describe any major construction, renovations, or modifications (in the past six months/since last visit).

____

____

____

2. Describe any specific weatherization, or building tightening actions taken during the same period.

____

____

____

D. INTERNAL MAINTENANCE AND DECOR

1. Have any changes been made in this building (in the last six months/since last visit) which include the addition or application of any of the following items?

				Specify and Indicate Surface Area
a.	Furniture, drapes	☐ No .	☐ Yes .	______________
b.	Synthetic carpet	☐ No .	☐ Yes .	______________
c.	Wallpaper	☐ No .	☐ Yes .	______________
d.	Interior paint	☐ No .	☐ Yes .	______________
e.	Ceiling, floor finishes .	☐ No .	☐ Yes .	______________
f.	Plywood, particle board .	☐ No .	☐ Yes .	______________
g.	Foam insulation	☐ No .	☐ Yes .	______________
h.	Interior paneling	☐ No .	☐ Yes .	______________
i.	Other (Specify ________ ______________)	☐ No .	☐ Yes .	______________

2. a. How often is the interior of this building treated with pesticides?

____

b. When was the last time this building was treated?

____

c. By whom was the building last treated?

Name: ____________________

Address: ____________________

____

Telephone Number: (__________) ____________________

d. What product(s) (was/were) used and in what quantit(y/ies)?

____

____

e. Describe formulation, application instructions and other details of application.

____

____

____

____

3. Describe cleaning products generally used in this building. Include soaps, waxes, deodorants, disinfectants, polishes, etc.

Product	Quantity Used in Average Month	Frequency of Application	Last Application

E. EXTERNAL INFLUENCES

1. Describe any pressure gradients present in this structure, especially those near potential sources of the pollutants of interest.

____

____

____

____

2. Meteorological data:

   a. Outside temperature: high _____°F low _____°F (average for date)

   b. Outside relative humidity: ______________________________

   c. Wind speed and direction: ______________________________

   d. Barometric pressure and tendency: ______________________________

3. Outdoor Air Monitoring Results:

____

____

____

____

4. Describe any unique occurrence in building or immediate surroundings during past seven days and twenty-four hours? Include such things as fires, chemical spills, etc.

____

____

____

____

RTI Study #2190-38 Form #3

TEAM Indoor Air Study

MONITOR LOCATION QUESTIONNAIRE

March 1983

RESEARCH TRIANGLE PARK, NORTH CAROLINA 27709

PURPOSE

This instrument will collect data about the specific locations in which the monitoring devices are placed and will relate to the time period monitored. Thus, one copy will be completed for each monitoring location, for each twenty-four hour period. As in Form #2, this document contains sections which collect information that is unlikely to change between periods. If no changes occur in Section A, check the appropriate box and proceed to Section B. If changes have occurred, enter information concerning only the changed items.

Building Address: ____________________

Specific Site Location: ____________________

Date Monitoring Started: ______/______/______

Time Monitoring Started: ____________________

Time Monitoring Ended: ____________________

Monitoring Period # 1 2 3 (circle one)

A. GENERAL DESCRIPTION OF MONITORING LOCATION

If no change from previous monitoring period, check box, and go to Section B.

☐ No Change

1. Describe the use of the location.

____

____

____

2. What are the dimensions of the location?

Length: __________ feet

Width: __________ feet

Height: __________ feet

If not uniform, describe: ____________________

____

____

3. a. Approximately how many feet above the nearest roadway is the location?

______ feet

b. Is the building located on a hill?

☐ Yes ☐ No

4. Describe in full the HVAC system for this location. Include information on fixed and movable parts of the system, and any abnormalities noted.

______

______

______

5. a. What are the "R" values for the insulation in the:

(1) walls in the location? . . . . . ______

(2) floors in the area? . . . . . . ______

(3) ceilings in the area? . . . . . ______

b. Is there weather stripping on the windows and outside doors in the location? Was it added since the original construction?

(1) Windows: ☐ Yes ☐ No ☐ NA ☐ New ☐ Original

(2) Doors: ☐ Yes ☐ No ☐ NA ☐ New ☐ Original

6. In the location, is there:

a. any foam insulation?

☐ Yes → Age ______, Square footage ______

☐ No

b. any polyurethane product?

☐ Yes → Description, including age and square footage: ______

______

______

☐ No

7. In the location, is there:

a. plywood subflooring? . . . ☐ Yes . ☐ No . ☐ DK . __________ sq. ft.

b. wall paneling? . . . . . . ☐ Yes . ☐ No . ☐ DK . __________ sq. ft.

c. composition board? . . . . ☐ Yes . ☐ No . ☐ DK . __________ sq. ft.

8. In the location, are there any:

a. plastic construction materials?

☐ Yes → Describe and give age and square footage: ____________

____

☐ No

b) particle board items?

☐ Yes → Describe and give age and square footage: ____________

____

☐ No

9. Identify and give age of each item of furniture in this location.

Item	Age	Construction/Material	Approximate Surface Area

10. Describe type, surface area, and give age of any wall coverings in the location, including backing material and glue/paste.

____

____

____

____

11. Describe any carpeting in the location.

a. Age: ______________________________________

b. Fibers: ___________________________________

c. Backing: __________________________________

d. Glues: ____________________________________

e. Surface area: ______________________________

B. CONDITIONS DURING MONITORING PERIOD

1. What is the average number of occupants in the location?

a. Day: __________

b. Night: __________

2. Give number of smokers present in the location during the monitoring period. If any, give percent of time present and approximate total amount of tobacco smoked. If more than one, provide information for each.

	#1	#2	#3	#4	#5
a. % of time present .					
b. Amount smoked . . .					
c. What smoked					

3. During the monitoring period what was the:

	Day	Night	
a. average temperature?			degrees
b. relative humidity?			percent

4. Identify any pets present during monitoring period; if any, give percent of time present and presence of flea collars or use of flea powders.

____

____

5. During the monitoring period, did anyone engage in any of the following hobbies in the location?

a. Woodworking? . . . . ☐ Yes . ☐ No . ☐ DK

b. Painting? . . . . ☐ Yes . ☐ No . ☐ DK

c. Ceramics/Pottery? . . . . ☐ Yes . ☐ No . ☐ DK

d. Photographic developing? . . . . ☐ Yes . ☐ No . ☐ DK

e. Other (Specify ______________________) ☐ Yes . ☐ No . ☐ DK

6. a. Describe number and kind of any pest strips in the location.

____

____

b. Specify any pesticides used and time of use. Contact pesticide applicator for specific details on type and amounts, including formulation and application instructions.

____

____

____

____

7. Were any windows in the location open during the monitoring period?

☐ Yes → Number open: ____________; % of time open: ____________

☐ No

☐ NA

8. a. Is there a gas cooking stove in the location?

☐ Yes ☐ No → (GO TO b.)

↓

(1) Is it vented? . . . . ☐ Yes . ☐ No

(2) Does it have a pilot light? . . . . . ☐ Yes . ☐ No

(3) What percent of the time was it in use? ________%

b. Is there a gas or kerosene space heater in the location?

☐ Yes, gas ☐ No

☐ Yes, kerosene

↓

(1) Is it vented? . . . . ☐ Yes . ☐ No

(2) Does it have a pilot light? . . . . . ☐ Yes . ☐ No

(3) What percent of the time was it in use? ________%

9. a. Was a free-standing stove or fireplace in the location in use during the monitoring period?

☐ Yes ☐ No

↓

(1) Percent of time in use ______________%

(2) Energy source ________________________

(3) Vented? ☐ Yes ☐ No

b. Was a clothes dryer in the location in use during the monitoring period?

☐ Yes ☐ No

↓

(1) Percent of time in use ______________%

(2) Energy source ________________________

c. Was a humidifier in use in the location during the monitoring period?

☐ Yes ☐ No

↓

(1) Percent of time in use ______________%

10. When was the area last:

a. vacuumed? ____

b. dusted? ____

11. What is the rate of air exchange in the:

a. kitchen, if applicable? ______________________________

b. rest of location? __________________________________

12. Were any filters or particle scavengers in use?

☐ Yes → Describe: __________________________________

____

☐ No

13. Complete Table 3.1 to describe use of household and other chemical products in the location during monitoring period.

14. Describe the types of activities undertaken in the location during the monitoring period.

____

____

____

____

____

____

15. Outside meteorological data:

	Day	Night
a. Average temperature		
b. Relative humidity		
c. Wind speed and direction		
d. Barometric pressure and tendency .		

Table 3.1

Household Products

Product	Number of Hours Since Last Use	Amounts Used	Frequency of Use	Surface Area Covered
A. Cleaning Products				
1.				
2.				
3.				
4.				
5.				
6.				
7.				
B. Aerosol Products				
1. Drugs/Bronchodilator				XXXXXXX
2. Vaporizer				XXXXXXX
3. Hair Products				XXXXXXX
4. Personal Hygiene				XXXXXXX
5. Deoderant				XXXXXXX
6. Foot Spray				XXXXXXX
7.				XXXXXXX
C. Housekeeping Products				
1. Disinfectants				
2. Waxes				
3. Bathroom/Kitchen Deoderants				
4.				
5.				
6.				
7.				

Form #4

RTI Study #2190-38

TEAM Indoor Air Study

GENERAL INTERVIEW INFORMATION

March 1983

Site #: ____________________

Dates of Interview: _____/_____/_____ to _____/_____/_____

A. Provide details on the persons interviewed to collect the information in Forms 1-3. Provide names, addresses, phone numbers, and positions. Detail the difficulty involved in collecting this data.

B. Provide complete details of any unusual situations of occurrences encountered during this monitoring season.

APPENDIX B

RECONSTRUCTED ION CHROMATOGRAMS RICs OF HEADSPACE EXPERIMENTS

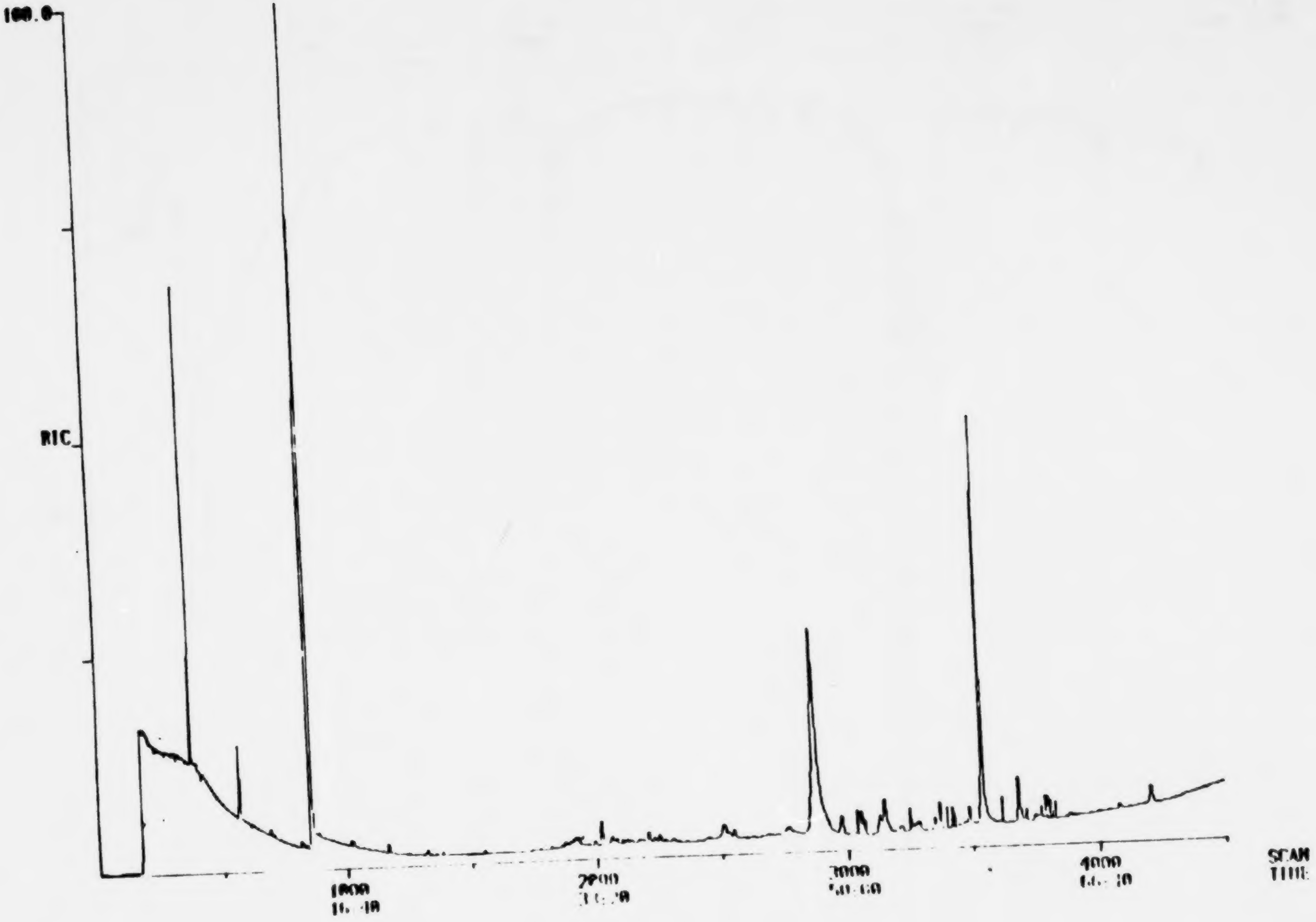

Figure B-1. RIC of blank (empty vessel purged with He gas).

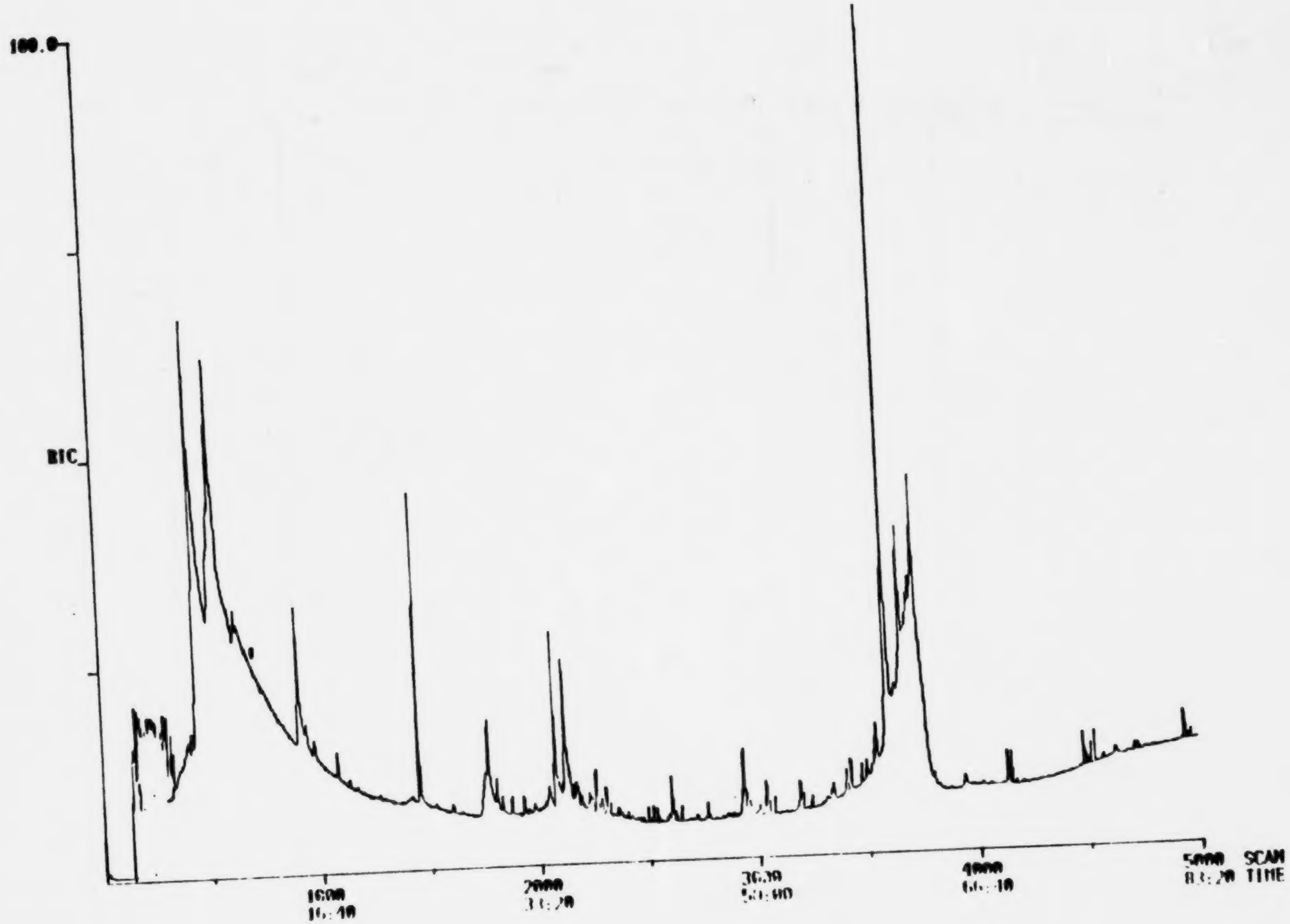

Figure B-2. RIC of headspace for TALON G.

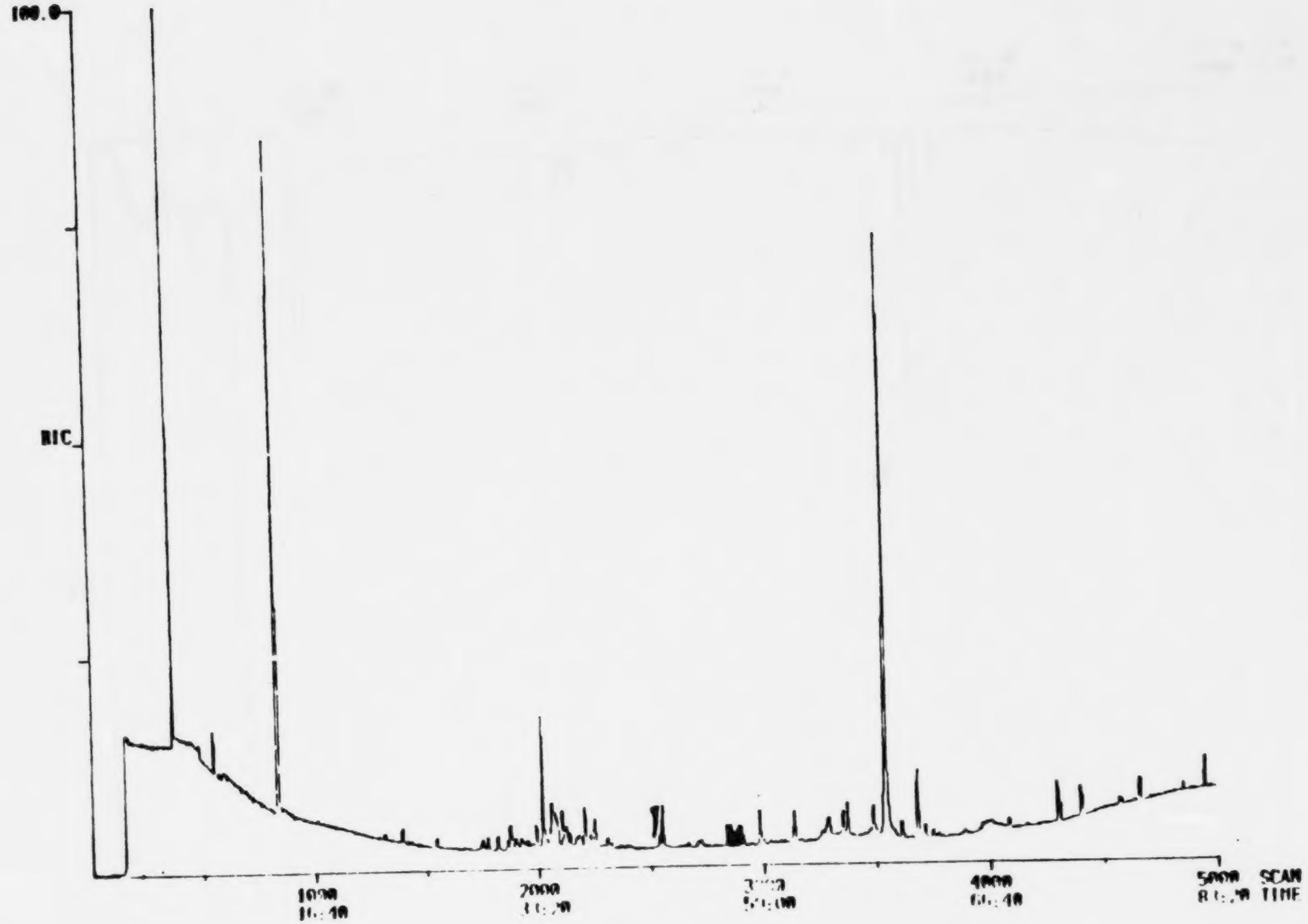

Figure B-3. RIC of headspace for Armstrong Fissured Minaboard Ceiling.

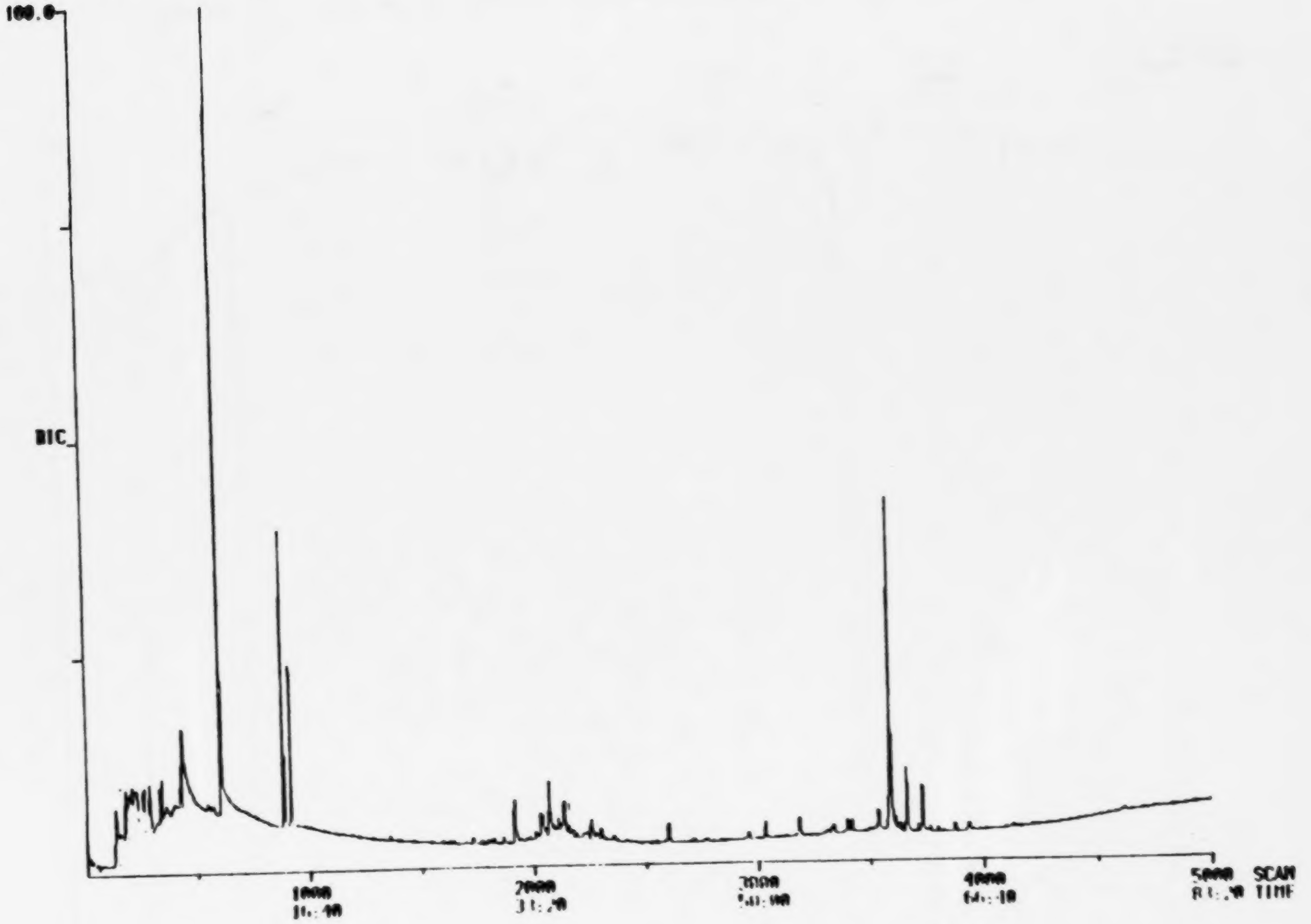

Figure B-4. RIC of headspace for FICAM material.

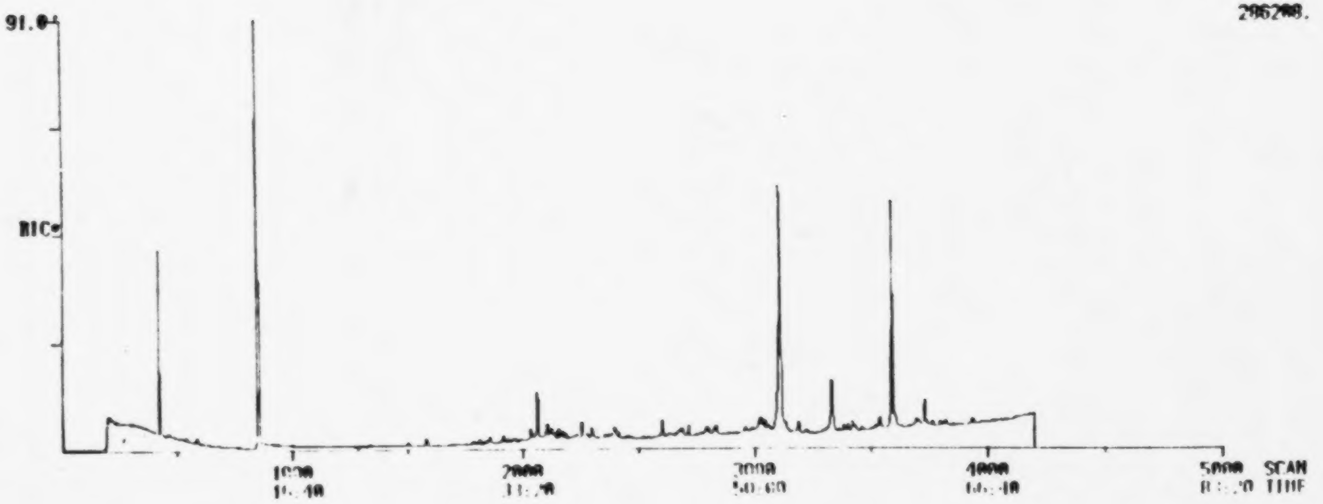

Figure B-5. RIC of headspace for Old Dutch Cleanser.

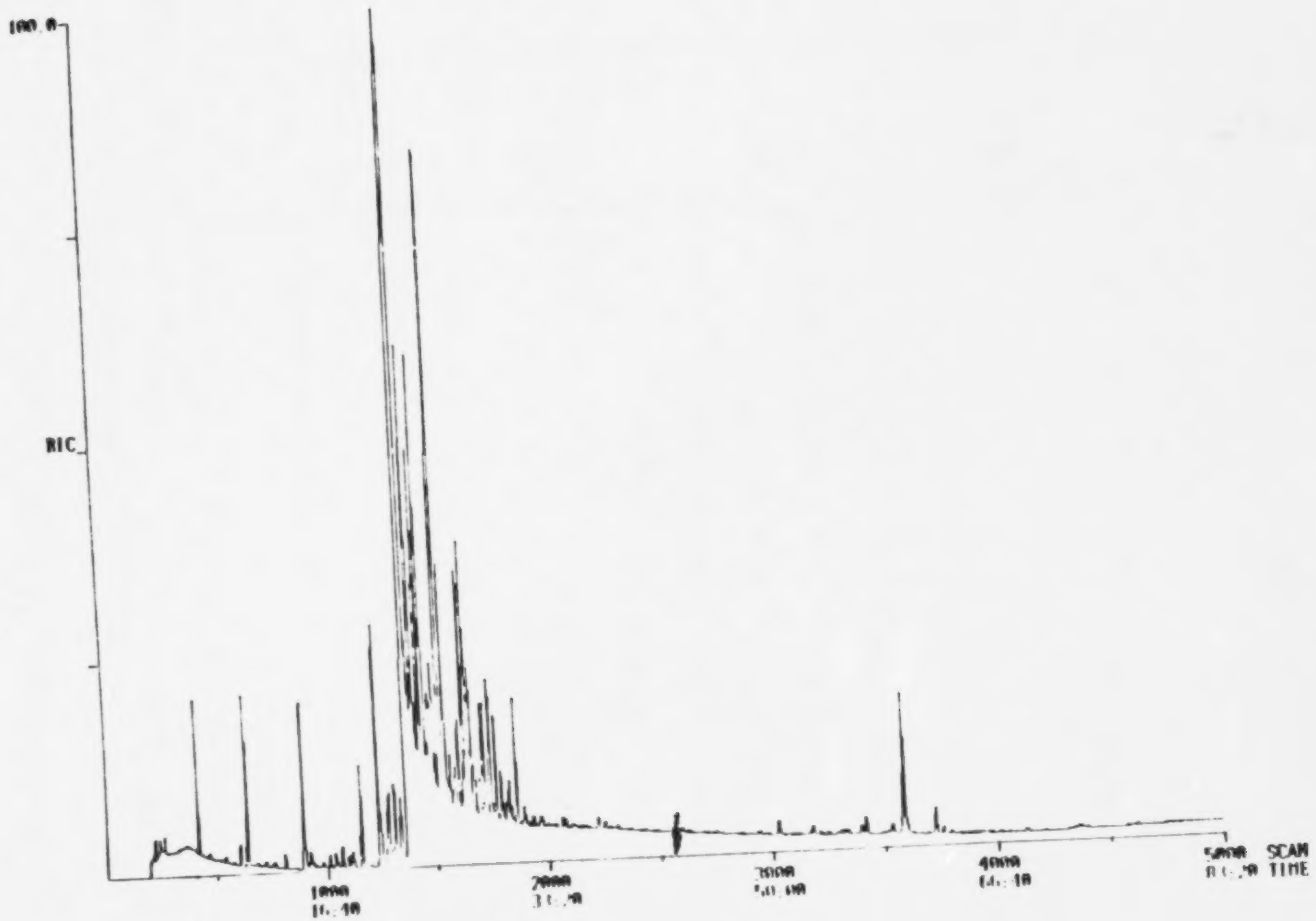

Figure B-6. RIC of headspace from carpet glue.

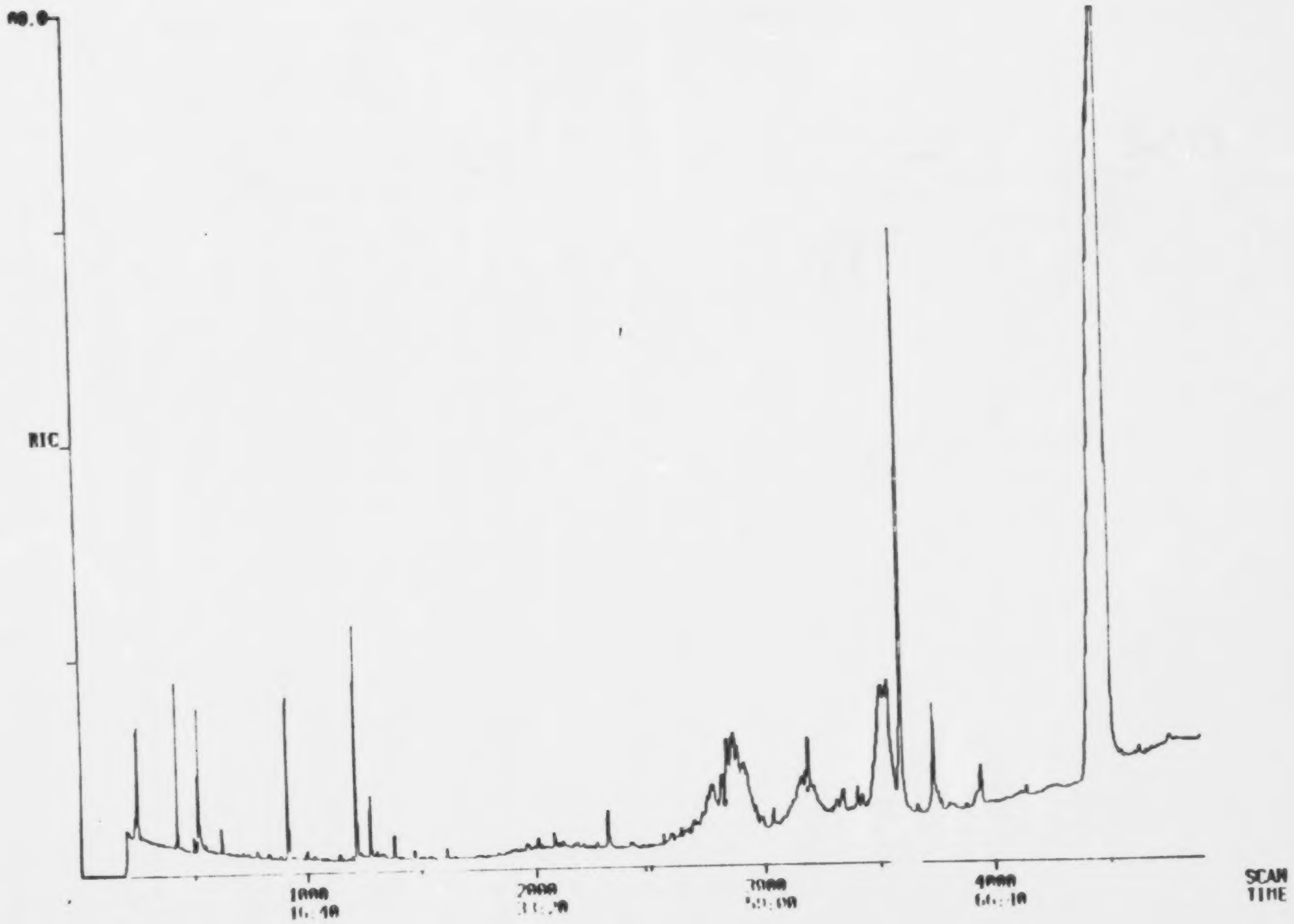

Figure B-7. RIC of headspace for Seventy-seven material.

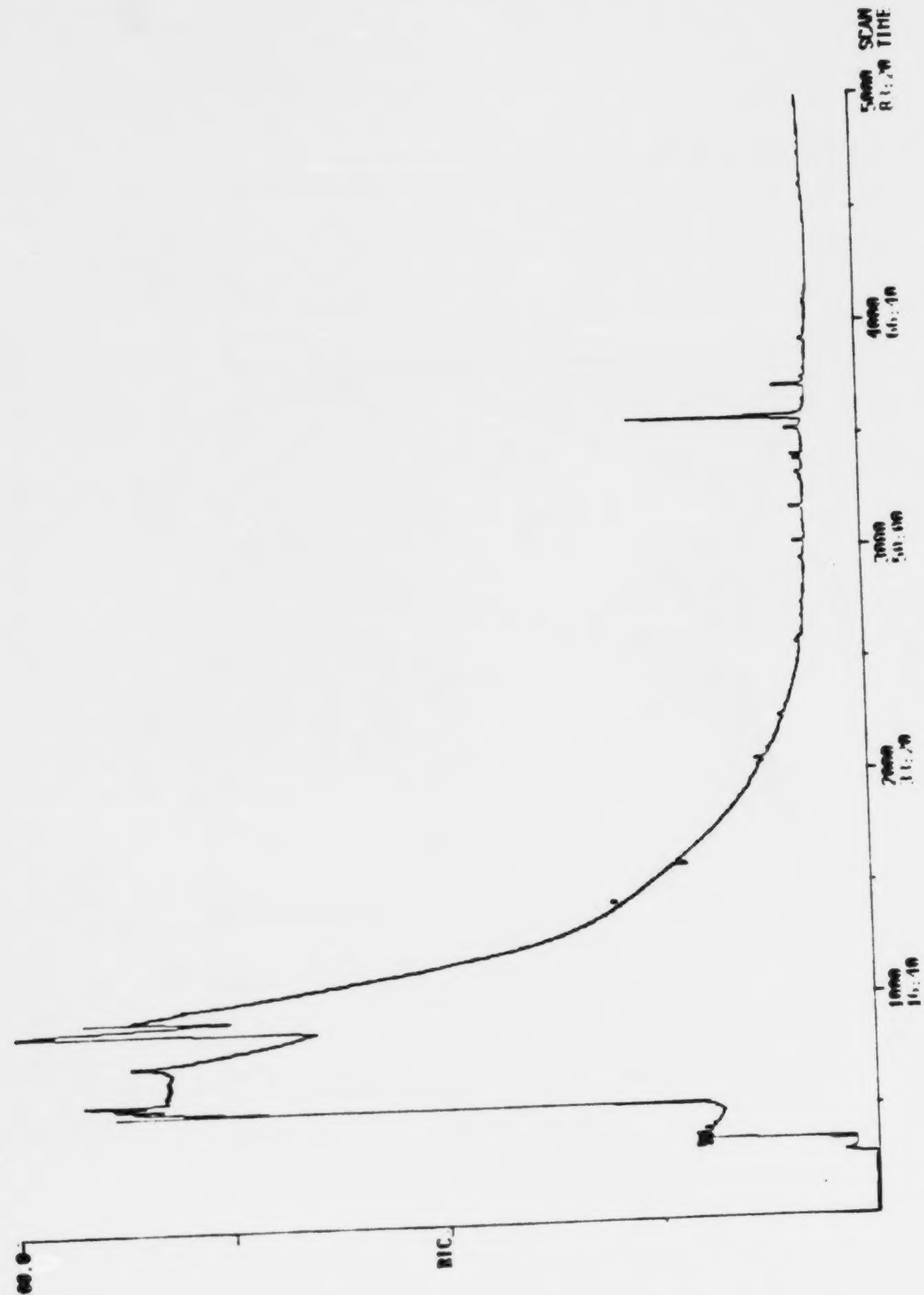

Figure B-8. RIC of headspace from PT-250 material.

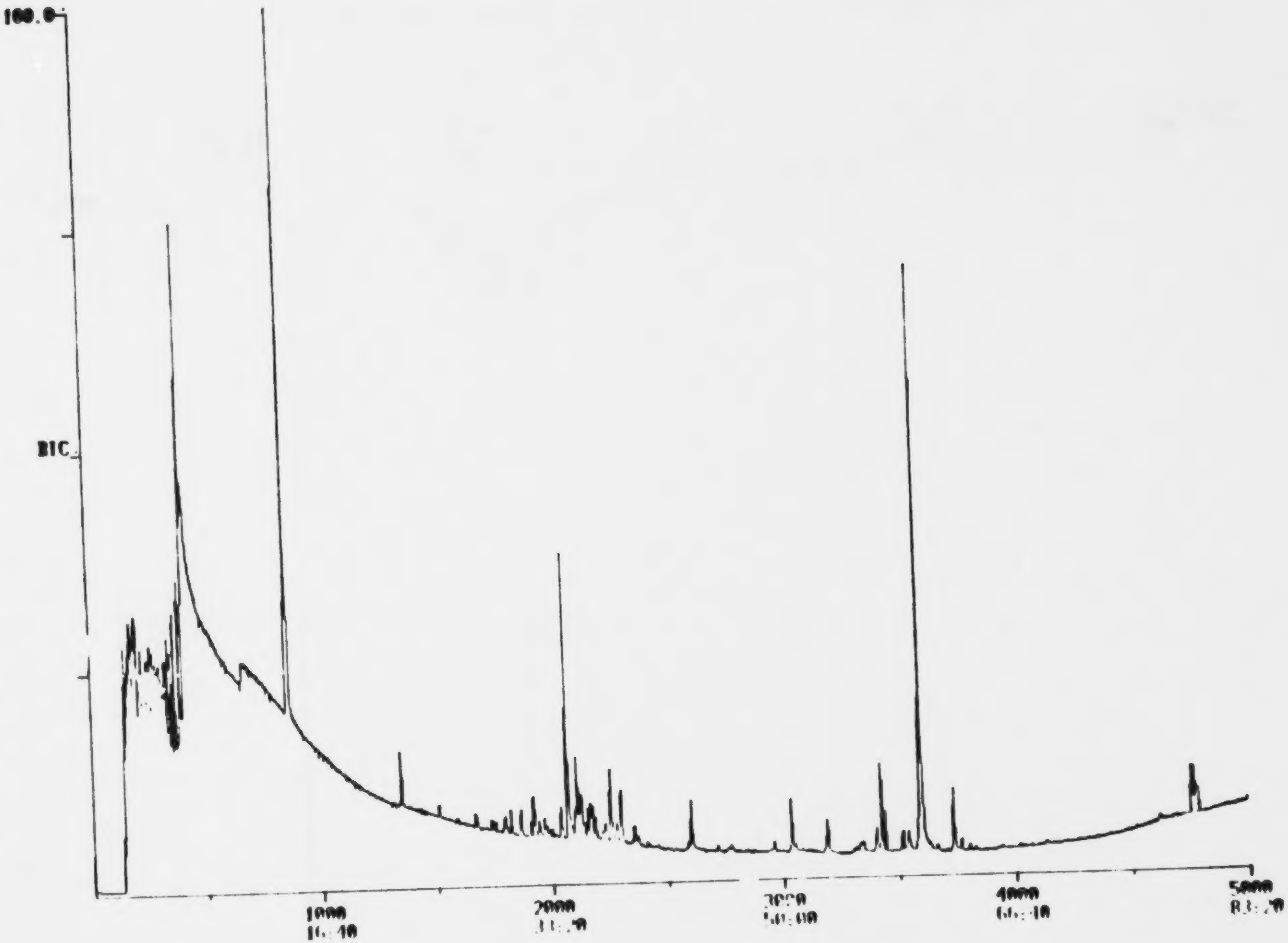

Figure B-9. RIC of headspace from carpet.

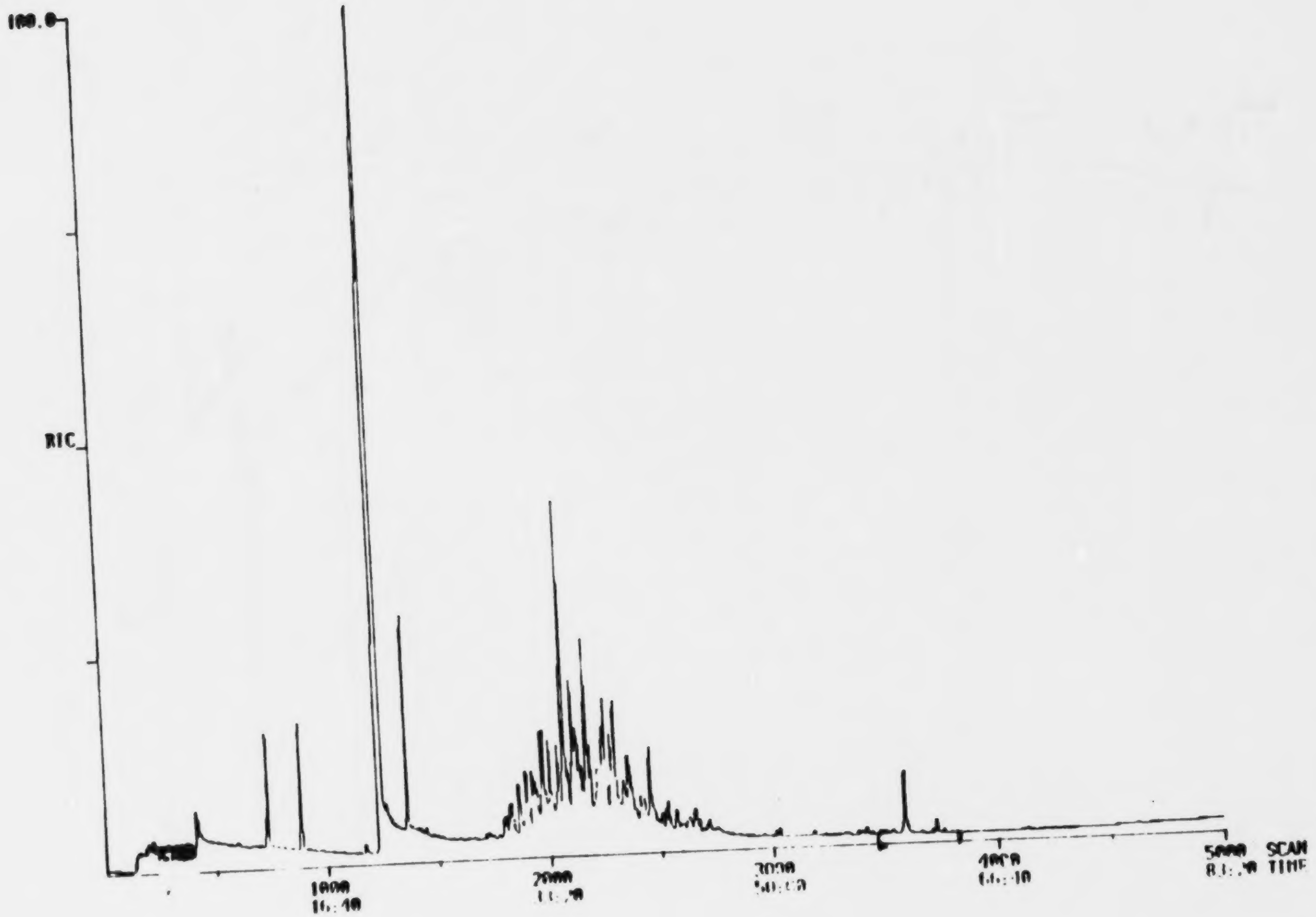

Figure B-10. RIC of headspace from non-smooth carpet.

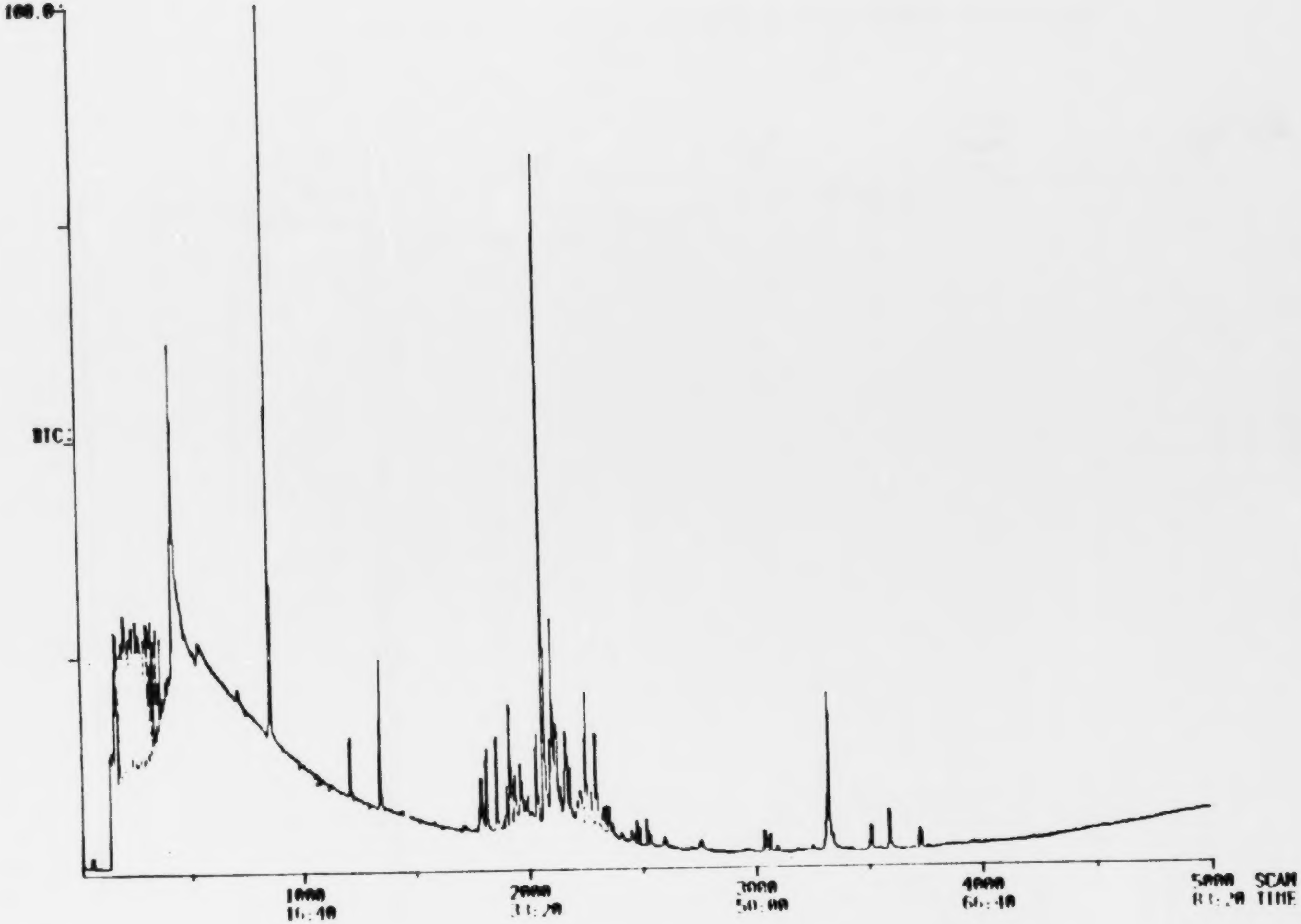

Figure B-11. RIC of headspace from sheetrock.

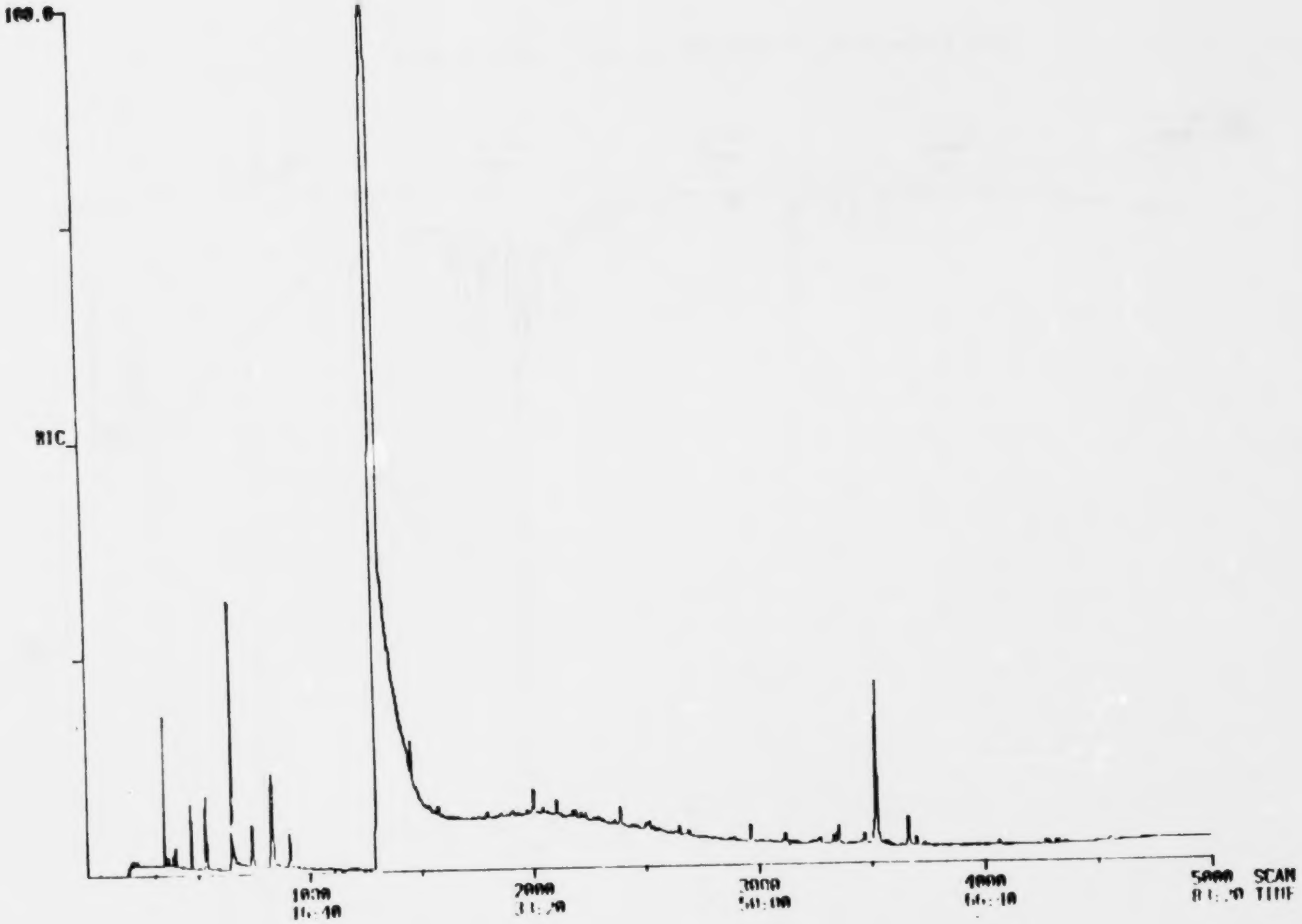

Figure B-12. RIC of headspace from Borden E8825 film.

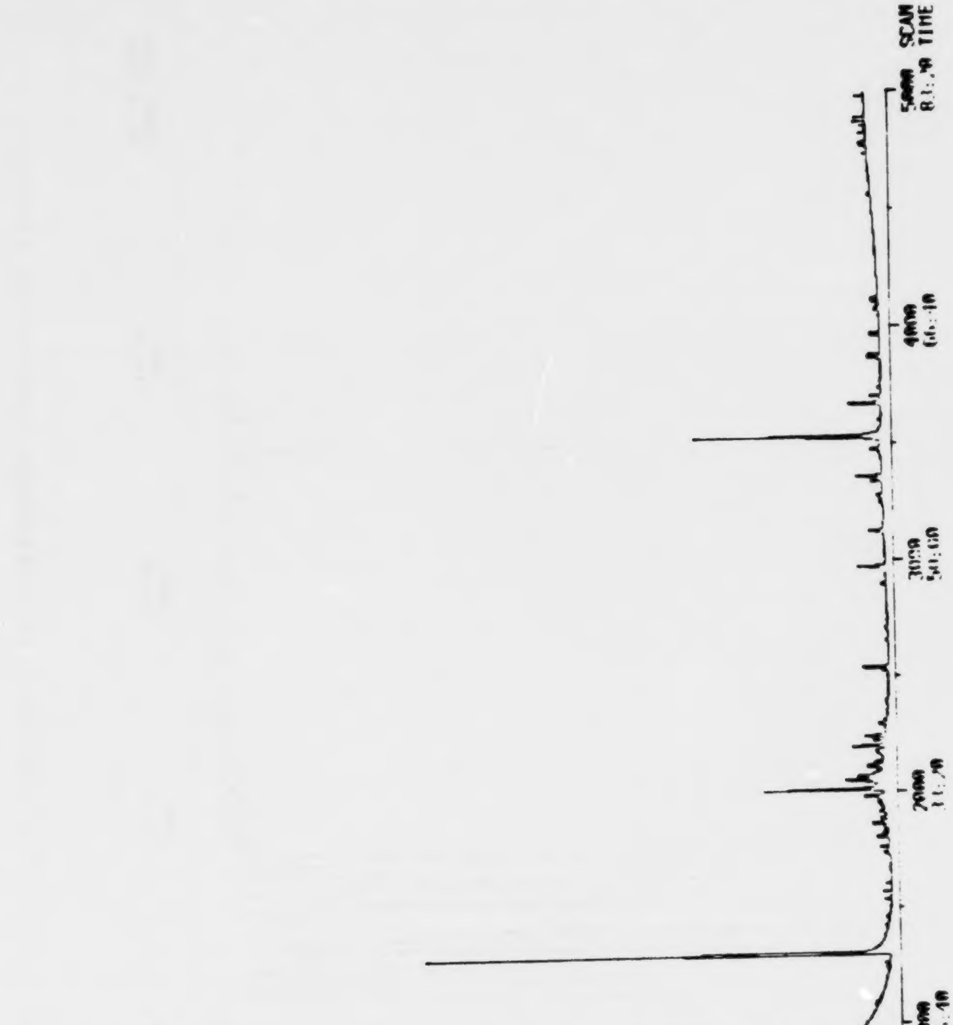

Figure B-13. RIC of headspace from 650 (surface applied).

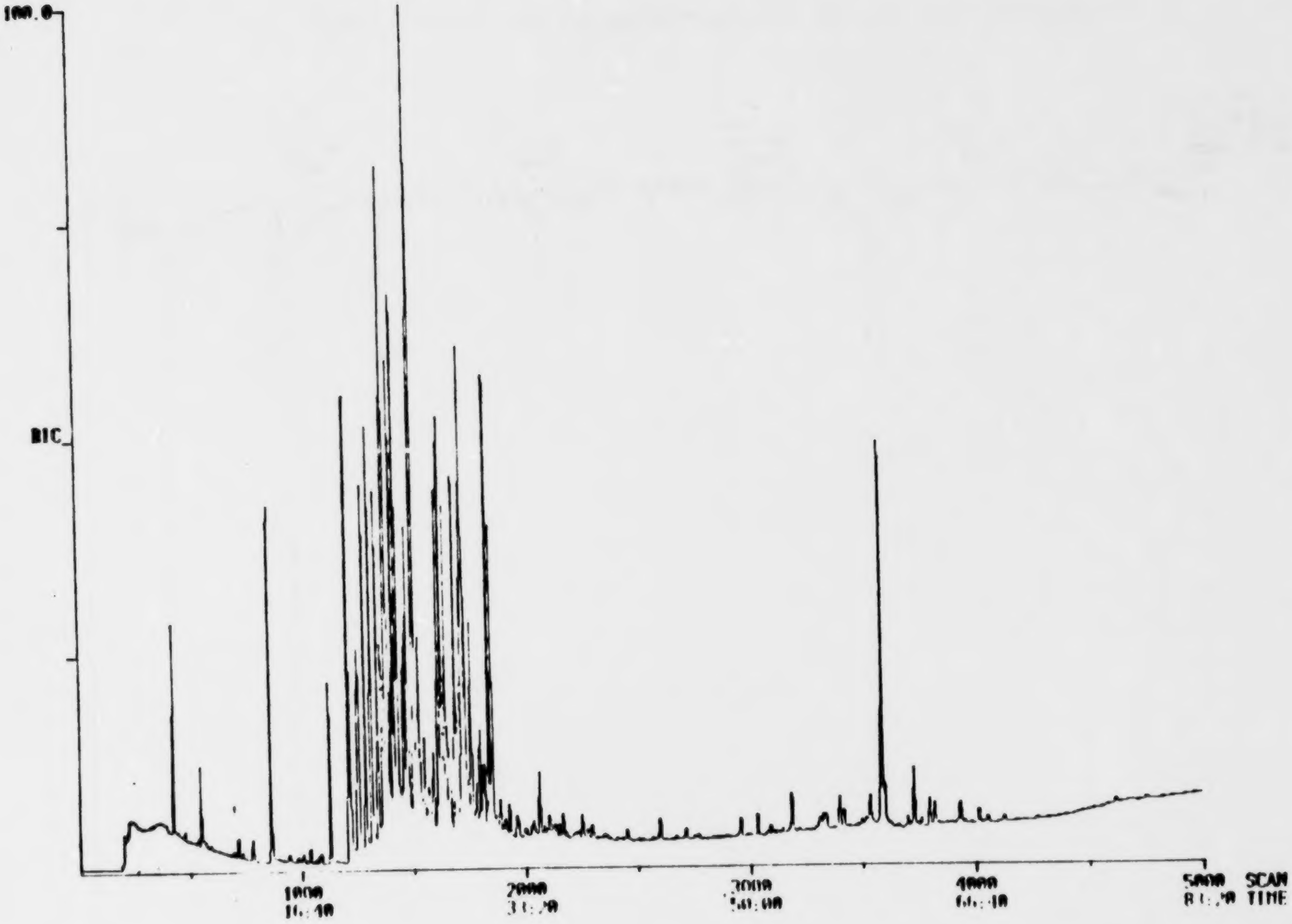

Figure B-14. RIC of headspace from stainless steel polish cleaner.

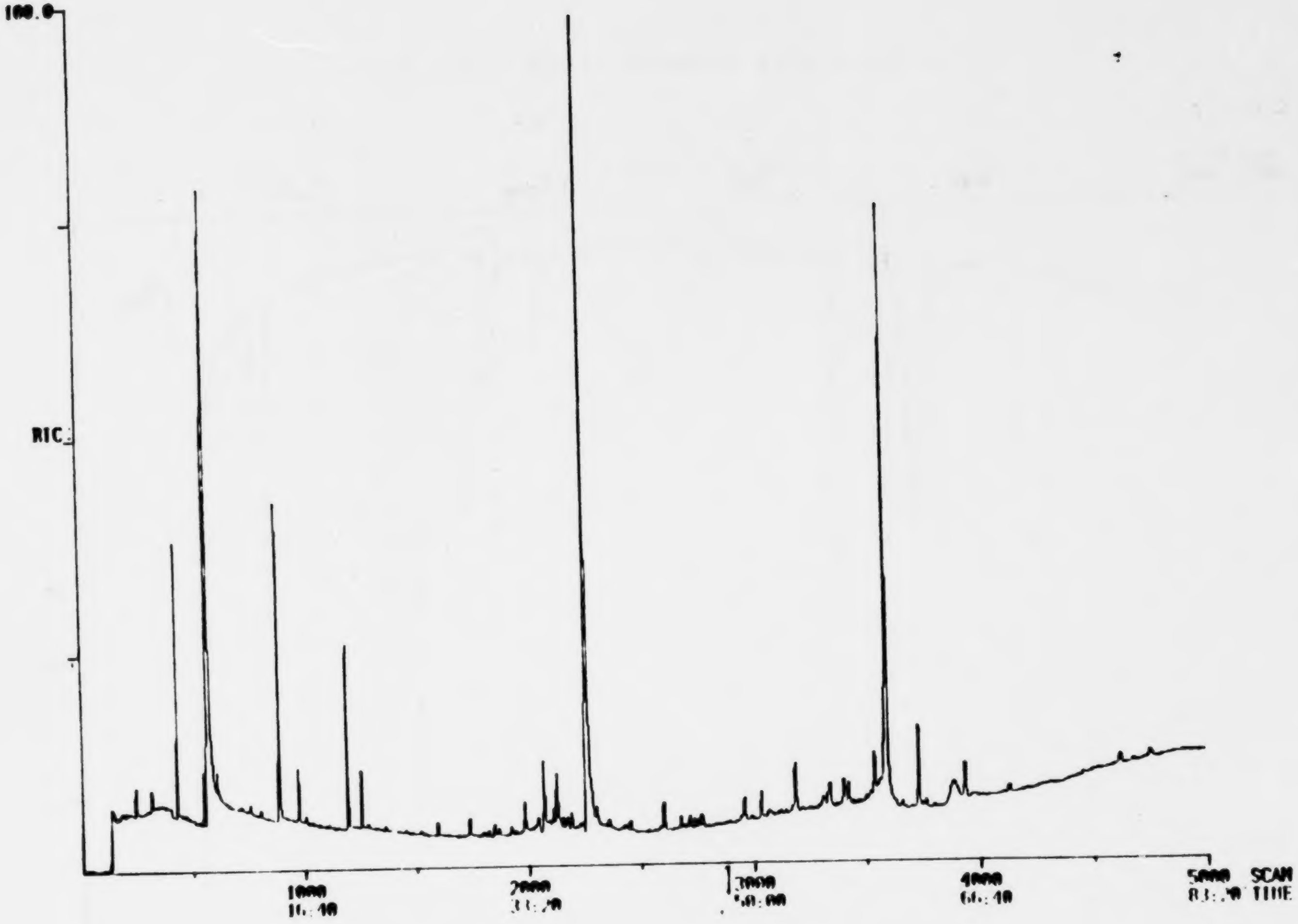

Figure B-15. RIC of headspace from Seventy-seven material.

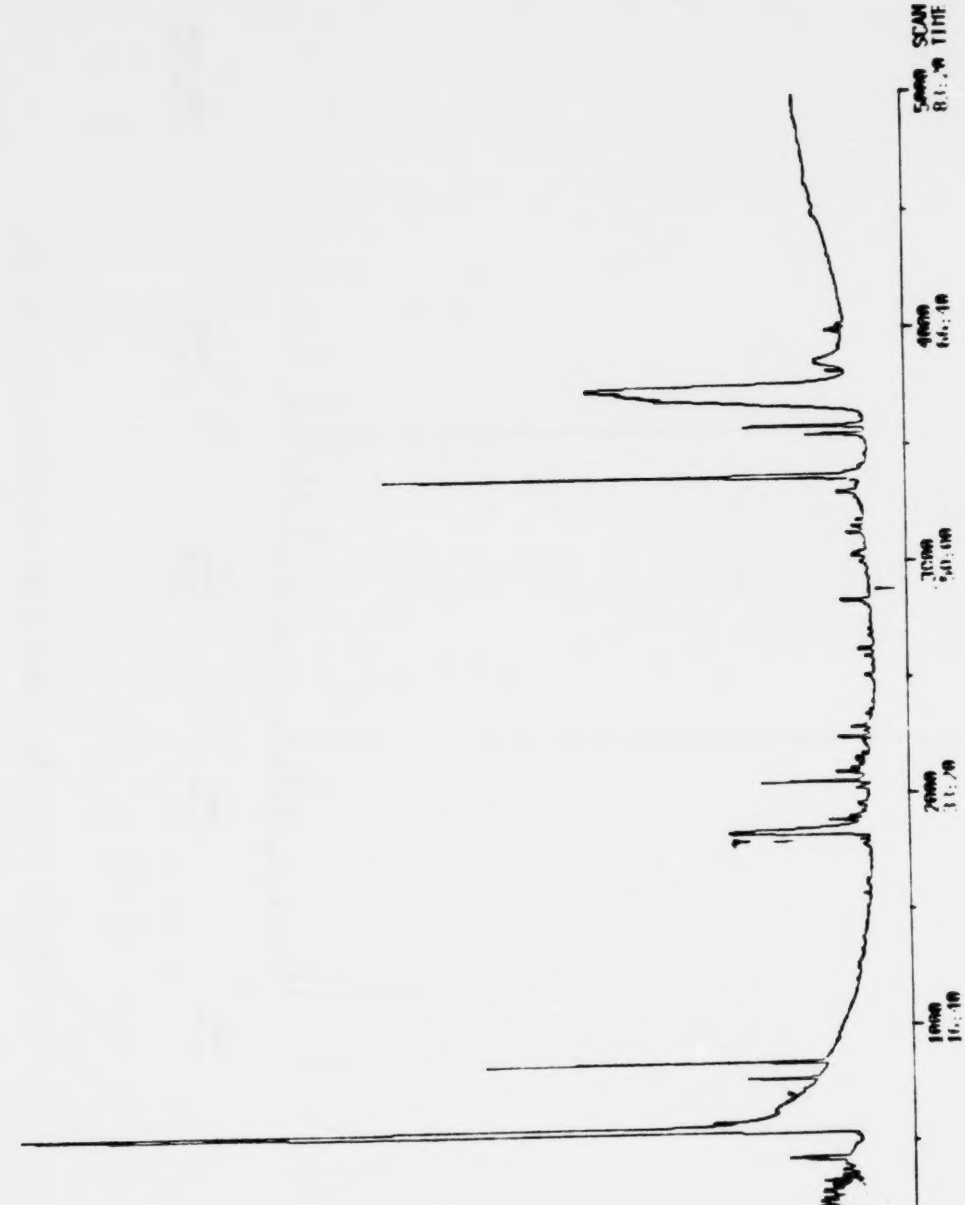

Figure B-16. RIC of headspace from Brillo VC.

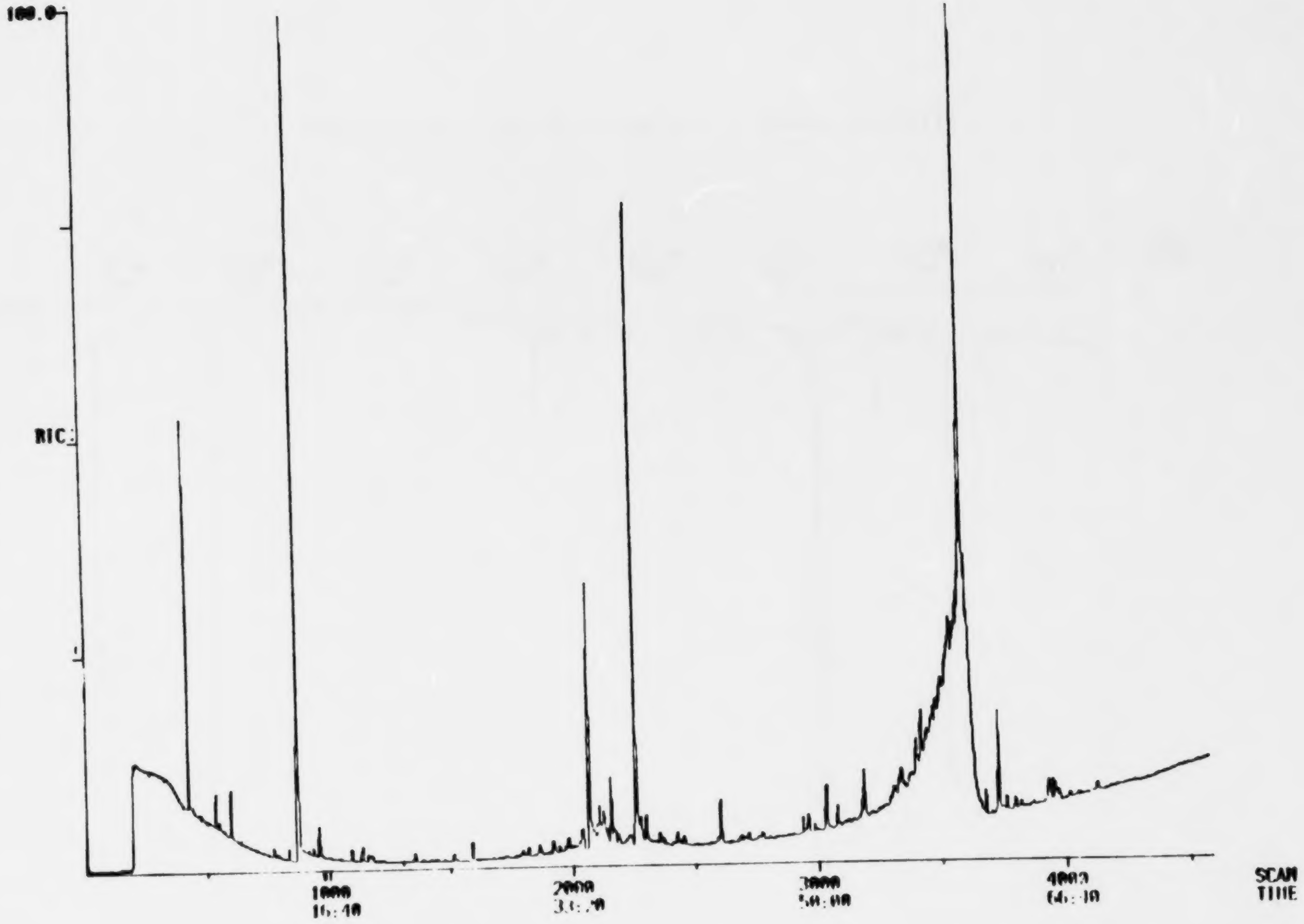

Figure B-17. RIC of headspace from Lemon Speedway wax.

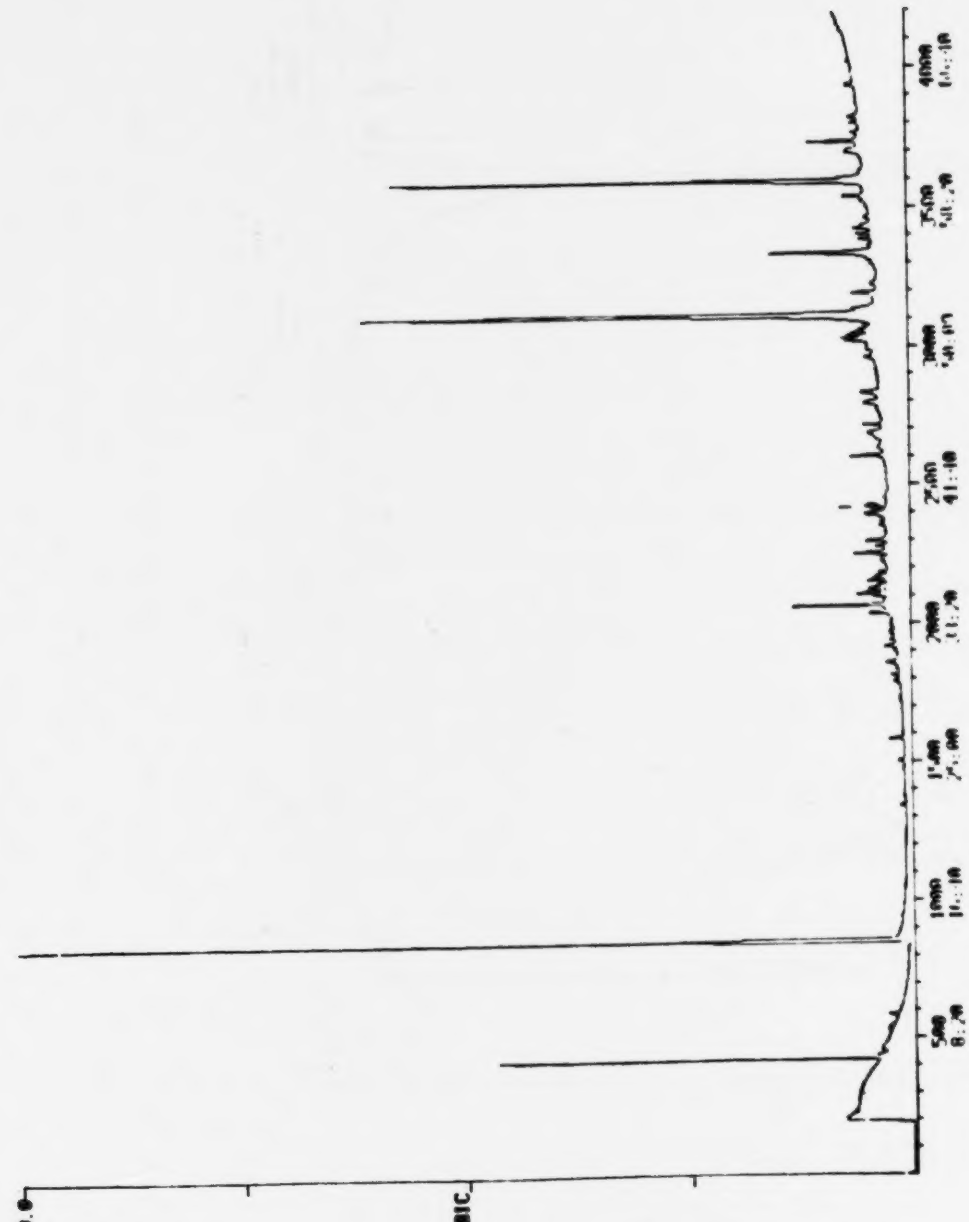

Figure B-18. RIC of blank No. 2 (empty vessel).

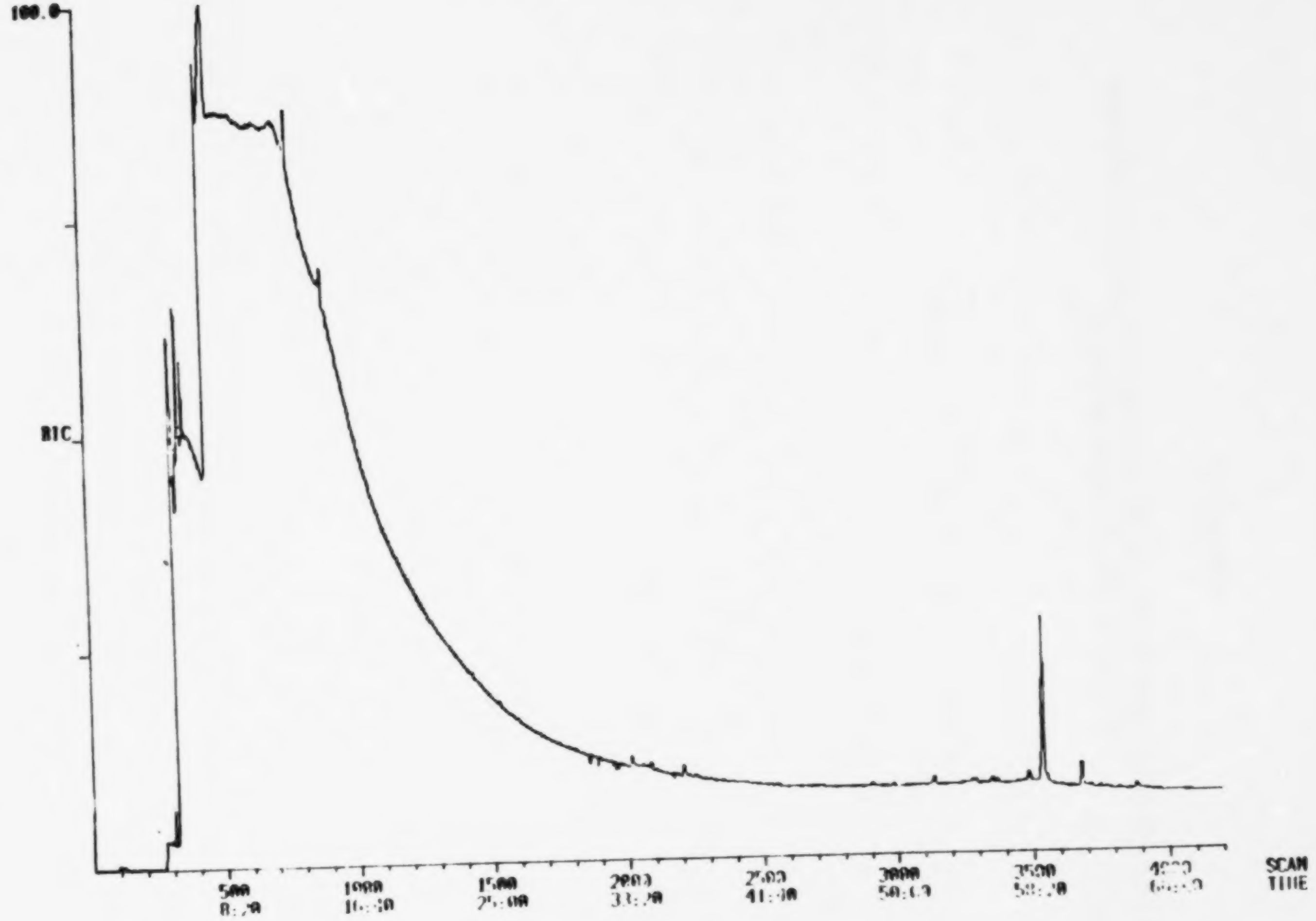

Figure B-19. RIC of headspace from PT-110.

APPENDIX C

VOLATILE ORGANICS IDENTIFIED IN THE HEADSPACE OF VARIOUS BUILDING MATERIALS AND CONSUMER PRODUCTS

TABLE C-1. ORGANICS IN BLANK (EMPTY VESSEL)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
427008	CO_2	381			
16063	dichloromethane	572	958	975	978
812032	PFT (external standard)	857			
391680	Adhesive peak from septum	2874			
593920	Adhesive peak from septum	3541			
3103	1,1,1-trichloroethane	887	786	885	843
4183	chloropentafluorobenzene	322	797	851	929
	siloxane	1522			
35584	HC[a] (manual)	2022			
13344	HC (manual)	2204			
87552	hexyl acetate	3152	489	894	495

[a] HC = hydrocarbon.

TABLE C-2. ORGANICS IN HEADSPACE OF TALON G

RIC Area	Compound	Scan #	Purity	Fit	R Fit
376320	oxoacetic acid	543	779	876	808
25951	methylene chloride	634	937	983	948
184576	PFT	913			
2391	3-methylbutanal	945	692	932	705
18912	2-methylbutanal	981	886	923	910
13486	pentanal	1084	882	952	897
62335	2-ethylcyclobutanal	1457	890	925	890
4751	2,4-dimethylheptane	1533	791	957	799
42367	diethylcyclobutane	1753	684	900	702
72959	2-heptanone	1774	864	973	874
23239	heptanal	1810	653	862	653
13551	trimethylheptane	1833	868	968	878
15663	ethylmethylheptane	1876	906	976	906
2604	$C_{11}H_{22}$ HC (manual)	1906			
1866	HC[a] (manual)	1918			
18527	trimethylheptane	1932	835	956	847
5415	4-methylnonane	1955	819	945	844
7657	trimethyloctane	1979	814	960	831
33663	trimethyloctane	2078	903	966	903
3812	HC (manual)	2110			
22591	2-pentyl furan	2125	897	997	897
6104	HC (manual)	2174			
12016	HC (manual)	2181			
6343	trimethylnonane	2238	838	979	847
12656	HC (manual)	2248			
7743	pentamethylhephtane	2263	915	966	918
12304	HC (manual)	2288			
15872	HC (manual)	2307			
3612	HC (manual)	2362			
1738	HC (manual)	2377			
4311	chloroform	842	791	822	962
20864	1,1,1-trichloroethane (manual)	946	-	-	-
6960	chlorobenzene (manual)	1650	-	-	-
5086	ethylbenzene (manual)	1714	-	-	-
42112	m,p-xylene (manual)	1743	-	-	-
9566	o-xylene (manual)	1821	-	-	-
22400	decane (manual)	2077	-	-	-
5000	trimethyloctane	2721	756	944	780
6424	HC (manual)	2776			
169427	$C_{10}H_{16}$ HC (manual)	2930			
10335	dimethyl-2-methylene bicyclo-bicyclo[2.2.1]heptane	2940	750	991	750
16864	HC (manual)	2964			
27647	trimethyldecane	3192	738	982	738
3856	HC (manual)	3332			
26336	HC (manual)	3344			

(continued)

TABLE C-2 (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
27776	HC (manual)	3407			
40255	diethyl phthalate	3543	533	968	547
21983	1-(4-hydroxy-3-methoxy-phenyl)-ethanone	3667	555	933	587
12096	HC (manual)	3804			
7464	HC (manual)	3826			

[a] HC = hydrocarbon.

TABLE C-3. ORGANICS IN HEADSPACE OF FICAM MATERIAL

RIC Area	Compound	Scan #	Purity	Fit	R Fit
74624	cyclopropane, 1,1,- dibromo-2-chlorofluoro	429	800	969	819
2105340	methylene chloride	609	947	974	958
866304	PFT	889			
4624	ethylbenzene	1703	752	934	800
18208	dimethylbenzene	1733	810	966	837
9712	HC[a] (manual)	1800			
6648	C_8H_{10} HC	1811			
11680	HC (manual)	1824			
15696	5-ethyl-2-methylheptane	1868	830	962	843
107240	1-methylethylbenzene	1917	914	998	914
13168	propylbenzene	2012	746	985	751
66432	trimethylbenzene	2033	846	982	847
51008	trimethylbenzene	2042	706	972	706
3520	chloroform (manual)	815			
451444	1,1,1-trichloroethane	921	778	985	781
21088	m,p-xylene (manual)	1732			
13600	o-xylene (manual)	1811			
244224	decane (manual)	2071			
66432	ethyl-3-methylbenzene	2034	824	998	824
51008	ethylmethylbenzene	2042	681	986	688
32480	trimethylbenzene	2057	921	993	921
135680	tetramethylbutane	2072	697	968	699
12632	ethylmethylbenzene	2091	713	985	713
8272	HC (manual)	2103			
33280	HC (manual)	2112			
100480	trimethylbenzene	2138	908	995	905
26848	methyl undecane	2167	793	914	831
22784	HC (manual)	2175			
10736	HC (manual)	2190			
7656	HC (manual)	2231			
14336	trimethylbenzene	2223	919	783	930
29952	HC (manual)	2244			
50688	dimethyl decane	2258	748	966	751
30080	HC (manual)	2283			
31776	dimethyl undecane	2031	847	949	858
2892	HC (manual)	2345			
14896	HC (manual)	2358			
10016	HC (manual)	2372			
3200	HC (manual)	2455			
7704	HC (manual)	2718			
20576	HC (manual)	2961			
49600	HC (manual)	3189			
34496	trimethyl decane	3403	798	986	798
----	?	3735			
27630	2,6-bis(1,1-dimethylethyl)- 4-ethylphenol	3937	709	908	743

[a] HC = hydrocarbon.

TABLE C-4. ORGANICS IN HEADSPACE OF OLD DUTCH CLEANSER

RIC Area	Compound	Scan #	Purity	Fit	R Fit
83072	methylene chloride	608	902	982	916
22848	chloroform	809	844	957	877
603136	PFT	883			
8272	tetramethylpentane	1798	846	840	866
13616	HC^a (manual)	1822			
14864	dimethylnonane	1866	857	953	877
3564	trimethylhexane	1909	711	935	740
23008	ethylmethylhexane	1921	885	975	890
4664	ethylmethylhexane	1946	826	917	874
8005	HC (manual)	1170			
186624	trimethyloctane	2069	868	960	881
13792	trimethyloctane	2101	739	961	746
35264	trimethyloctane	2111	765	957	775
14768	HC (manual)	2124			
21344	HC (manual)	2130			
21888	2,4-dimethyldecane	2166	872	976	873
24512	HC (manual)	2175			
11520	HC (manual)	2188			
36160	1,1,1-trichloroethane	916	605	854	619
70	benzene (manual)	968			
232960	decane (manual)	2069			
864	HC (manual)	2231			
14160	HC (manual)	2241			
19808	dimethyldecane	2256	847	969	848
20960	HC (manual)	2280			
16512	dimethylundecane	2300	833	950	843
14928	HC (manual)	2356			
6304	HC (manual)	2371			
725	HC (manual)	2411			
1324	HC (manual)	2439			
1084	trimethyldecane	2454	771	951	789
18752	?	2564			
21376	HC (manual)	2716			
10368	?	2771			
12240	$C_{10}H_{16}$HC (manual)	2807			
85760	$C_{10}H_{16}$HC (manual)	2838			
685056	trimethyl bicyclo [-2.2.1-1] heptan-2-ol, acetate	2927	657	978	657
314368	1-methyl-(1-methyl ethenyl) cyclohexane	2959	666	995	666
2054140	dimethylmethylene bicyclo [-2.2.1-]heptane	2937	748	992	748
138752	$C_{10}H_{16}$HC (manual) 2,2-dimethyl-2-methylene bicyclo [-2.2.1-]	3012			
41727	heptane	3626	701	989	701
6359	2-methyl-t-propylhexane	3186	775	980	775

(continued)

TABLE C-4. (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
23264	?	3340			
29472	HC (manual)	3401			
32575	diethylphthalate	3537	501	957	521
16047	hexyl acetate	3731	480	913	485
11564	HC (manual)	3798			
2544	HC (manual)	3822			
8016	?	3936			
5448	HC (manual)	4019			
29984	HC (manual)	4368			

[a] HC = hydrocarbon.

TABLE C-5. ORGANICS IN HEADSPACE OF CARPET GLUE

RIC Area	Compound	Scan #	Purity	Fit	R Fit
6799	butane	542	849	849	917
549	methylpropane	573	867	867	977
5343	methylene chloride	609	968	983	979
45759	cyclopentadiene	641	988	992	988
1999	cyclopentene	684	932	932	980
21184	?	713			
6703	methylpentane	724	916	943	951
763	?	746			
7807	methylpentane	762	856	889	932
3647	hexane	811	953	975	966
352768	PFT	899			
3619	C_6H_8 (manual)	925	-	-	-
8511	1-methyl-1,3-cyclopentadien	936	878	975	895
8303	benzene	981	896	937	934
19423	cyclohexane	1013	928	989	928
18431	methylhexane	1038	947	978	964
4295	dimethylpentane	1047	849	934	904
3759	dimethylcyclopentane	1059	773	904	845
5351	methylhexane	1070	977	994	981
12303	dimethylcyclopentane	1097	914	988	922
11327	dimethylcyclopentane	1107	883	941	891
20127	dimethylcyclopentane	1117	904	990	912
27103	heptane	1158	983	997	983
22143	trimethylcyclopentane	1250	876	944	900
59007	methylcyclohexane	1241	949	998	949
6415	dimethylhexane	1277	785	795	979
12031	dimethylhexane	1285	926	938	955
14879	5-methylheptene	1314	807	925	822
98431	trimethylcyclopentane	1338	896	962	930
114815	toluene	1380	929	985	942
19423	dimethylhexane	1388	947	959	985
53696	HC^a (manual)	1393			
94591	2-methylheptane	1407	944	967	952
534528	?	1413			
12495	dimethylhexane	1421	966	977	987
81023	3-methylheptane	1436	460	994	960
75007	HC (manual)	1453	-	-	-
26719	dimethylcyclohexane	1459	897	967	923
4063	trimethylhexane	1471	940	945	989
56191	dimethylcyclohexane	1479	952	977	966
43583	ethyl methyl cyclopentane	1486	910	944	957
331776	HC (manual)	1493	-	-	-
25311	ethyl methyl cyclopentane	1499	945	994	945
569344	octane (manual)	1523	-	-	-
154111	octane	1527	984	992	984
53375	ethyl methyl cyclohexane	1457	802	989	802

(continued)

TABLE C-5. (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
46207	trimethylcyclohexane	1569	809	952	809
22144	HC (manual)	1586			
9215	dimethylheptane	1595	939	941	986
22527	dimethylheptane	1610	963	978	965
60991	nonane	1631	756	969	756
357376	HC (manual)	1646	-	-	-
27327	trimethylheptane	1654	885	935	917
1238	HC (manual)	1664	-	-	-
45184	HC (manual)	1674	-	-	-
8096	HC (manual)	1684	-	-	-
9504	HC (manual)	1696	-	-	-
20384	HC (manual)	1703	-	-	-
29599	trimethylcyclohexane	1716	942	996	942
56512	HC (manual)	1725	-	-	-
5343	dimethylbenzene	1733	708	984	717
5144	HC (manual)	1738	-	-	-
43072	HC (manual)	1749	-	-	-
10719	octahydropentalene	1761	952	991	952
75776	HC (manual)	1773	-	-	-
23872	HC (manual)	1795	-	-	-
4120	HC (manual)	1808	-	-	-
4768	HC (manual)	1817	-	-	-
8960	HC (manual)	1824	-	-	-
23616	HC (manual)	1832	-	-	-
4752	HC (manual)	1840	-	-	-
1758	HC (manual)	1851	-	-	-
171520	HC (manual)	1862	-	-	-
1740	HC (manual)	1887	-	-	-
6680	HC (manual)	1895	-	-	-
10128	HC (manual)	1908	-	-	-
4112	HC (manual)	1924	-	-	-
10959	cyclopropylcyclohexane	1937	827	950	835
5639	4-methylnonane	1947	804	905	871
2287	propylcyclohexane	1969	854	969	877
4036	HC (manual)	1976	-	-	-
1108	$C_{10}H_{22}$ HC (manual)	2002	-	-	-
4624	HC (manual)	2041	-	-	-
5096	HC (manual)	2069	-	-	-
1721	1-methyl-4-(1-methylethenyl)-cyclohexanol	2081	657	929	662
903	HC (manual)	2110	-	-	-
1520	HC (manual)	2127	-	-	-
4704	HC (manual)	2172	-	-	-
8752	?	2225			
11904	HC (manual)	2255			
3520	HC (manual)	2299			

(continued)

TABLE C-5. (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
2104	HC (manual)	2944	-	-	-
483	HC (manual)	2956	-	-	-
4119	dimethyldecane	3172	726	959	742
16207	dimethyldecane	3182	778	969	791
629	HC (manual)	3313	-	-	-
1404	HC (manual)	3325	-	-	-
7592	HC (manual)	3337	-	-	-
5184	HC (manual)	3398	-	-	-
6136	?	3535			
1918	HC (manual)	3600	-	-	-
41599	hexyl acetate	3729	511	914	517
2324	HC (manual)	3797	-	-	-
408	$C_{13}H_{28}$ HC (manual)	3819	-	-	-
803	HC (manual)	4017	-	-	-
15152	1,1,1-trichloroethane	927	569	938	600
5288	benzene	981	950	950	990
5152	ethylbenzene	1705	412	849	459
9168	m,p-xylene (manual)	1733	-	-	-
47872	styrene (manual)	1794	-	-	-
2372	o-xylene (manual)	1811	-	-	-

[a] HC = hydrocarbon.

TABLE C-6. ORGANICS IN HEADSPACE OF SEVENTY-SEVEN

RIC Area	Compound	Scan #	Purity	Fit	R Fit
---	CO_2	253			
---	unidentified	427			
292864	ethanol	520	985	988	986
60096	dichloromethane	622	969	984	980
19328	3-methylpentane	779	938	969	954
15008	hexane	828	807	968	827
7976	tetrahydrofuran	881	847	891	949
557056	PFT	915			
21504	benzene	999	978	993	980
8880	cyclohexane	1031	916	977	916
---	unidentified	1141			
---	siloxane	1185			
735232	2,4,4-trimethyl-1-pentene	1216	967	999	967
184576	trimethyl-2-pentene	1277	952	999	952
64000	methylbenzene	1382	933	998	933
21184	trimethyl-2-pentene	1470	911	992	911
---	siloxane	1612			
4720	tetramethylpentane	1837	790	960	793
4000	4-methylnonane	1937	813	949	829
28896	trimethyloctane	1965	929	968	933
39936	chloromethylbenzene	2012	905	981	909
12384	chloromethylbenzene	2027	889	976	895
---	siloxane	2072			
44608	siloxane HC (manual)	2082			
9648	1-methoxy-3-methylbenzene	2105	737	817	791
---	siloxane	2117			
---	siloxane	2167			
16480	HC[a] (manual)	2184			
12860	$C_{12}H_{26}$HC (manual)	2209			
6728	HC (manual)	2253			
116096	ethoxymethylbenzene	2318	928	999	928
17952	undecane	2424	870	938	922
188672	HC (manual)	3195			
2662390	3,4,5-trimethyl-1-hexene	3592	566	893	573
408064	hexyl acetate	3741	493	914	498
52320	2,6-bis(1,1-dimethyl-ethyl)-4-ethylphenol	3939	770	944	774
30998500	dihexyl ester nonanedioic acid	4457	406	571	424

[a] HC = hydrocarbon.

TABLE C-7. ORGANICS IN HEADSPACE OF PT-250

RIC Area	Compound	Scan #	Purity	Fit	R Fit
1916920	2-methylpropanol	583	756	869	756
539648	2-propanone	529	840	876	856
19365800	1,1-dichloro-1-nitroethane	917	732	948	739
100864	PFT (manual; coeluted)	945			
103040	HC[d] (manual)	2062			
---	siloxane (manual)	3025			
93824	HC (manual)	3177			
1478650	3,4,5-trimethyl-1-hexene	3581	578	845	591
---	siloxane (manual)	3411			
230565	hexyl acetate	3722	486	908	492
7479290	chloroform (manual)	549			
5554170	1,1,1-trichloroethane (manual)	970	757	965	761
190578000	methylene chloride (manual)	570			

[a] HC = hydrocarbon.

TABLE C-8. ORGANICS IN HEADSPACE FROM CARPET

RIC Area	Compound	Scan #	Purity	Fit	R Fit
7823	methylbenzene	1351	868	957	894
1335	bromohexane	1513	808	903	875
326	tetramethyl hexane	1798	913	913	995
1848	HC[a] (manual)	1822	-	-	-
3680	HC (manual)	1866	-	-	-
1102	HC (manual)	1909	-	-	-
4632	HC (manual)	1923	-	-	-
1336	HC (manual)	1947	-	-	-
921	HC (manual)	1971	-	-	-
165	HC (manual)	1986	-	-	-
181	HC (manual)	1995	-	-	-
3524	HC (manual)	2042	-	-	-
22712	HC (manual)	2071	-	-	-
3360	HC (manual)	2104	-	-	-
7120	HC (manual)	2112	-	-	-
2220	HC (manual)	2127	-	-	-
1462	HC (manual)	2131	-	-	-
2596	HC (manual)	2168	-	-	-
854	HC (manual)	2176	-	-	-
1296	HC (manual)	2191	-	-	-
242	HC (manual)	2223	-	-	-
1840	HC (manual)	2233	-	-	-
184	HC (manual)	2242	-	-	-
12208	HC (manual)	2258	-	-	-
2984	HC (manual)	2283	-	-	-
4128	HC (manual)	2302	-	-	-
438	HC (manual)	2348	-	-	-
1192	HC (manual)	2358	-	-	-
575	HC (manual)	2373	-	-	-
650	HC (manual)	2592	-	-	-

[a] HC = hydrocarbon.

TABLE C-9. ORGANICS IN HEADSPACE FROM NON-SMOOTH CARPET

RIC Area	Compound	Scan #	Purity	Fit	R Fit
22738	2-butanone	738	974	993	978
250880	PFT	888	-	-	-
3188	1,1,1-trichloroethane	919	-	-	-
1651	benzene	975	835	835	996
3837950	4-methyl-2-pentanone	1242	967	986	976
361472	methylbenzene (toluene)	1363	958	998	958
12512	chlorotetradecane	1734	536	766	616
78208	nonane	1862	931	987	933
155904	HC[a] (manual)	1926	-	-	-
104960	HC (manual)	1897	-	-	-
120448	HC (manual)	1969	-	-	-
137472	HC (manual)	1979	-	-	-
123136	HC (manual)	2005	-	-	-
142592	HC (manual)	2045	-	-	-
686080	HC (manual)	2072	-	-	-
243712	HC (manual)	2114	-	-	-
408064	HC (manual)	2174	-	-	-
223232	HC (manual)	2259	-	-	-
122368	undecane	2457	914	996	914
62400	HC (manual)	2537	-	-	-
144384	3,4,5-trimethylhexene	3589	595	879	595
22304	hexyl acetate	3731	515	914	515

[a] HC = hydrocarbon.

TABLE C-10. ORGANICS IN HEADSPACE FROM SHEETROCK

RIC Area	Compound	Scan #	Purity	Fit	R Fit
10080	CO_2	429	-	-	-
186173	PFT	661	-	-	-
88	m,p-xylene	1720	-	-	-
1431	decane (manual)	1915	-	-	-
2359	2-butanone	715	930	930	975
12511	4-methyl-2-pentanone	1211	823	890	857
31583	toluene	1343	919	997	919
3136	HC^a (manual)	1784			
4640	"	1790			
3268	"	1797			
7062	"	1814			
6632	"	1859			
1689	"	1889			
4248	"	1902			
5200	"	1921			
4632	"	1939			
3500	"	1945			
2872	"	1953			
5304	"	1964			
4456	"	1970			
9472	"	1980			
7472	"	1989			
3696	"	1998			
2884	"	2022			
6776	"	2036			
164351	trimethyloctane	2065	901	968	901
6464	HC (manual)	2097			
30719	"	2106			
5888	"	2114			
7304	"	2120			
7000	"	2125			
6880	"	2162			
6560	"	2169			
4984	"	2185			
3400	"	3317			
3968	"	2227			
3588	"	2237			
28319	trimethylnonane	2252	929	960	932
3820	HC (manual)	2277			
6808	"	2296			
2124	"	2342			
3084	"	2352			
2236	"	2368			
3928	"	2410			
2664	"	2453			
4112	"	2794			

(continued)

TABLE C-10. (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
64832	4,5-dimethylhexene	3324	587	885	595
8272	HC (manual)	3511			
13232	4,6,8-trimethylnonene	3591	633	819	679

[a] HC = hydrocarbon.

TABLE C-11. ORGANICS IN HEADSPACE FROM BORDEN E8825 FILM

RIC Area	Compound	Scan #	Purity	Fit	R Fit
31935	2-butanone	711	946	982	950
148224	PFT	858			
2132	1,1,1-trichloroethane	892	558		
55167	4-methyl-2-pentanone	1210	918	984	927
119295	methylbenzene	1342	943	998	943
4808		1789			
7120	"	1812			
9455	3,3,5-trimethylheptane	1857			
21728	HC (manual)	1915			
16928	"	2034			
94335	2,5,6-trimethyloctane	2061	868	960	980
25952	HC (manual)	2104			
35264	"	2249			
27104	"	2295			
	siloxane (manual)	2597			
	"	3030			
91903	3,4,5-trimethylhexene	3587	582	887	582
14015	hexyl acetate	3726	512	884	518

[a] HC = hydrocarbon.

TABLE C-12. ORGANICS IN HEADSPACE OF 650 (SURFACE APPLIED)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
1591	methylene chloride	545	966	978	982
374128	PFT	833			
115142	trichloroethane	863	776	985	780
986163	benzene	918	983	993	983
1666	n-dimethylbenzene	1673	666	800	823
87552	CO_2	360			
4199	3-methylisobutanone	657	846	846	932
718	3-methylpentane	697	855	855	992
8639	hexane	716	936	936	978
85247	toluene	1304	955	998	955
2011	1-butanol	1385	668	821	686
2299	octane	1462	597	880	647
732	dimethylheptane	1663	850	930	898
552	bromohexane	1728	668	807	716
872	HC[a] (manual)	1732			
3075	"	1741			
1367	"	1748			
8527	tetramethylpentane	1764	918	940	930
7943	$C_{10}H_{22}$ HC (manual)	1806			
4903	HC (manual)	1850			
23871	"	1867			
6535	"	1889			
5375	"	1911			
3992	"	1917			
977	"	1927			
1730	"	1936			
2946	"	1945			
5168	"	1957			
967	"	1967			
21954	"	1985			
110463	trimethyloctane	2011	913	968	915
7775	HC (manual)	2043			
20095	"	2052			
1921	"	2066			
7671	"	2106			
10415	"	2115			
7399	"	2130			
31583	$C_{12}H_{26}$ HC (manual)	2197			
11567	HC (manual)	2222			
25983	"	2242			
8512	"	2297			
3296	"	2311			
2235	"	2395			
	?	2529			
2715	HC (manual)	67 2657			
5432	"	[illegible]			

(Continued)

TABLE C-12. (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
15680	HC (manual)	3127			
2152	"	3248			
1514	"	3269			
	?	3280			
9743	HC (manual)	3341			
	?	3478			
5575	hexyl acetate	3672	497	914	503
4056	HC (manual)	3779			

[a] HC = hydrocarbon.

TABLE C-13. ORGANICS IN HEADSPACE OF STAINLESS STEEL POLISH CLEANER

RIC Area	Compound	Scan #	Purity	Fit	R Fit
464384	cyclopropane, 1,1-dibromo-2-chloro-3-fluoro	429	963	964	996
13152	butane	481	944	950	976
21024	HC[a] (manual)	538			
185600	2-propanol	550	904	984	904
10496	pentane	569	936	946	954
9936	dichloromethane	595	922	960	957
14272	2-methylpentane	697	911	936	926
61120	2-butanone	717	973	987	976
20192	3-methylpentane	735	916	977	930
72832	hexane	782	916	968	923
1558520	PFT	865			
11296	methyl acetate	947	722	762	730
12096	methyl ethyl acetate	944	855	872	864
19424	cyclohexane	984	848	955	848
31808	2-methylhexane	1008	868	987	892
10944	dimethylpentane	1017	730	966	747
48320	3-methylhexane	1041	942	942	945
14944	dimethylcyclopentane	1069	808	985	815
24096	methylheptene	1079	825	951	831
37952	dimethylcyclopentane	1090	852	986	859
620544	heptane	1130	976	996	976
2052090	methylcyclohexane	1216	941	998	941
830464	trimethylcyclopentane	1225	923	979	934
1564670	trimethylcyclopentane	1289	951	997	957
728064	dimethylhexane	1251	916	940	935
942080	dimethylhexane	1261	928	931	829
1726460	trimethylcyclopentane	1317	951	998	951
1538040	methylbenzene	1346	949	999	949
728064	dimethylhexane	1363	963	987	974
729088	ethylmethylpentane	1371	874	891	966
3010550	methylheptane	1384	934	964	934
1132540	HC (manual)	1391			
2256890	methylheptane	1413	936	979	955
2469880	dimethylcyclohexane	1432	915	974	915
1014780	dimethylcyclohexane	1438	890	959	919
424960	dimethylcyclohexane	1460	967	995	967
587776	ethylmethylcyclopentane	1467	931	978	947
1073150	ethylmethylcyclopentane	1481	943	998	943
194304	HC (manual)	1491			
3989500	octane	1511	970	982	970

(continued)

TABLE C-13. (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
692224	diethylcyclobutane	1522	736	857	780
704512	diethylcyclobutane	1530	917	994	917
232448	butylcyclopentane	1553	841	926	859
516608	2,4-dimethylheptane	1595	925	937	957
1345530	2,6-dimethylheptane	1617	912	979	924
1791990	ethylcyclohexane	1632	911	950	933
1345530	1,1,3-trimethylcyclohexane	1651	962	995	962
229632	1-ethyl-4-methyl cyclohexane	1671	822	919	875
1662970	ethylbenzene	1693	932	997	932
1667070	1,4-dimethylbenzene	1721	956	998	956
755712	1,3,5-trimethylcyclohexane	1704	801	808	901
794624	5-methylnonane	1714	851	915	894
2658300	2-methyl acetate-1-butanol	1730	953	974	970
1010680	2-methyloctane	1739	932	982	940
758764	3-methyloctane	1764	970	987	970
133858		1786	842	991	842
377344	1,2-dimethylbenzene	1803	955	998	955
518656		1824	939	976	948
1804280	pentyl acetate	1841	923	962	933
1038330	nonane	1855	969	998	969
83640		1885	856	949	884
132352	(1-propenyl)-cyclohexane	1931	864	972	864
83200	propylcyclohexane	1963	855	976	868
234496	2,2,6-trimethyloctane	2066	889	971	889
59904	HC (manual)	2107			
103680	decane	2169			
91776	HC (manual)	2254			
89216	siloxane (manual)	2601			
76288	tridecane	2960	808	965	814
160512	tetradecane	3187	805	977	817
81024	siloxane (manual)	3034			
127872	pentadecane	3401	883	985	894
2187260	3,4,5-trimethyl-1-hexene	3591	509	847	575
276480	hexyl acetate	3730	505	909	511
112000	HC (manual)	3798			
92610	"	3821			
116864	2,6-bis(1,1-dimethylethyl)-4-ethylphenol	3934	806	944	810
62464	HC (manual)	4019			
183	chloroform (manual)	791			
370	1,1,1-trichloroethane	898			
1045	benzene	952	936	936	989
51136	undecane (manual)	2424			

[a] HC = hydrocarbon.

TABLE C-14. ORGANICS IN HEADSPACE FROM SEVENTY-SEVEN MATERIAL

RIC Area	Compound	Scan #	Purity	Fit	R Fit
	air peaks	246,318;434			
81280	2-propanone	549	971	993	975
3559420	2-propanol	572	882	969	882
37632	dichloromethane	611	968	982	985
17920	3-methylpentane	759	929	965	944
19104	hexane	807	923	958	942
920576	PFT	892			
131328	benzene	977	970	996	970
20800	cyclohexane	1009	836	972	842
501760	2,4,4-trimethyl-1-pentene	1195	952	992	959
141824	2,4,4-trimethyl-2-pentene	1256	922	998	922
39296	acetate-2-methyl-1-heptanol	1740	920	994	921
76928	3,7,7-trimethyl bicyclo-[4.1.0]hept-3-ene	1986	819	975	819
176128	hydrocarbon (manually)	2072			
169728	7-methyl-3-methylene-1,6-octadiene	2127	748	997	748
3403770	1,7,7-trimethyl bicyclo-[2.2.1]hept-3-ene	2262	844	994	844
87040	siloxane (manual)	2604			
74880	hydrocarbon (manual)	2962			
73856	siloxane (manual)	3036			
147200	hydrocarbon (manual)	3190			
266752	hexylester acetic acid	3733	521	927	521
136960	2,6-bis(1,1-dimethylethyl)-4-ethylphenol	3937	822	942	827
47552	siloxane (manual)	4624			
1418	chloroform (manual)	816			
6168	1,1,1-trichloroethane (manual)	923			
4496	trichloroethylene	1109	841	989	926
6504	m,p-xylene	1732	707	923	760
4136	o-xylene (manual)	1812			
28864	undecane	2456	881	991	884
29440	dodecane	2717	879	998	884

[a] HC = hydrocarbon.

TABLE C-15. ORGANICS IN BRILLO VC HEADSPACE

RIC Area	Compound	Scan #	Purity	Fit	R Fit
6905850	1-methyl ethyl acetate	561	809	822	817
166144	trichloromethane	775	955	969	986
860160	PFT	845			
7528	3-methyl-2-pentanone	1250	898	907	938
14944	2-butanol	1566	575	669	590
5912	HC[a] (manual)	1773			
17696	HC (manual)	1780			
14704	HC (manual)	1788			
21632	trimethylheptane	1804	920	992	923
1705980	2-butoxyethanol	1845	917	981	917
75264	3-methyl-4-heptanone	1890	946	992	946
46784	HC (manual)	1907			
15760	"	1930			
18304	"	1955			
266240	trimethyloctane	2056	897	969	897
18528	HC (manual)	2088			
74112	"	2098			
63424	"	2116			
33536	"	2153			
40768	"	2162			
18784	"	2177			
84864	pentamethylheptane	2245	788	967	795
23072	HC (manual)	2270			
51968	"	2292			
104320	"	2836			
50880	siloxane (manual)	3028			
42432	HC (manual)	3126			
1880060	3,4,5-trimethyl-1-hexene	3369	579	845	586
1108	benzene (manual)	934			
463	ethylbenzene (manual)	1680			
2252	*m*,*p*-xylene (manual)	1710			
844	styrene (manual)	1773			
3312	*o*-xylene (manual)	1790			
9312	*o*-dichlorobenzene (manual)	2164			

[a] HC = hydrocarbon.

TABLE C-16. ORGANICS IN LEMON SPEEDWAY WAX HEADSPACE

RIC Area	Compound	Scan #	Purity	Fit	R Fit
317952	1,1-dibromo-2-chloro-fluorocyclopropane	428	966	966	999
32096	acetone	539	964	989	972
8512	isopropylalcohol	553	818	962	825
55744	methylene chloride	601	967	983	979
10928	2-methylfuran	776	995	995	995
4752	hexane	792	757	858	803
1726460	PFT	877			
48064	benzene	962	981	995	981
15136	HC[a] (manual)	1138			
	siloxane (manual)	1096			
11568	chloropentafluorobenzene	1354	541	861	587
8432	octane	1514	837	968	852
	siloxane (manual)	1592			
511488	6-methyl-5-hepten-2-one	2067	751	969	751
	siloxane (manual)	2158			
1173500	1,7,7-trimethylbicyclo-[2.2.]]hept-3-ene	2259	831	998	831
45248	HC (manual)	2301			
	siloxane (manual)	2604			
	siloxane (manual)	3037			
86528	HC (manual)	3190			
	siloxane (manual)	3423			
193024	hexyl acetate	3733	527	903	530
1558520	4,5-octanedione	3592	520	932	520
55808	2,6-bis(1,1-dimethylethyl)-4-ethylphenol	3934	677	935	688
767	1,1,1-trichloroethane (manual)	909			
801	tetrachloroethylene (manual)	1524			
815	ethylbenzene (manual)	1698			
3580	*m*,*p*-xylene (manual)	1728			
1664	*o*-xylene	1808			
236800	decane (manual)	2070			
7688	undecane (manual)	2856	911	973	921

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[a] HC = hydrocarbon.

TABLE C-17. ORGANICS IN BLANK NO. 2

RIC Area	Compound	Scan #	Purity	Fit	R Fit
117248	CO_2 (manual)	426			
4567	acetone	531	902	919	934
5567	isopropyl alcohol	543	699	972	703
12367	methylene chloride	589	946	973	965
2739	carbon disulfide	612	650	934	677
822	1-butanol	771	814	818	835
276480	PFT	855			
1327	benzene	940	701	910	760
1400	?	951			
7431	chloropentafluorobenzene	1341	712	864	812
2127	methylheptane	1378	809	944	838
980	methylheptane	1408	729	952	755
7351	octane	1504	776	970	789
1063	methyloctane	1614	538	826	560
389	HC[a] (manual)	1640			
1000	ethylbenzene	1691	634	712	864
1485	dimethylheptane	1713	588	934	619
2099	dimethylbenzene	1722	721	825	864
1509	methyl butyl acetate	1729	795	887	881
1503	trimethylheptane	1764	889	948	891
2427	HC (manual)	1784			
1223	trimethylheptane	1792	959	973	977
1451	HC (manual)	1799			
2403	trimethylheptane	1816	957	982	965
2791	pentyl acetate	1841	724	917	784
2519	trimethylheptane	1861	945	964	974
446	HC (manual)	1856			
1233	"	1891			
3751	"	1904			
2967	$C_{10}H_{22}$ HC	1917			
6615	methylnonane	1942	869	930	893
5207	trimethyloctane	1966	852	954	869
4575	trimethyloctane	1972	844	969	844
1507	methylnonane	1982	594	902	627
2775	trimethyloctane	1991	874	955	882
2907	HC (manual)	2000			
3475	"	2029			
5703	"	2039			
28447	trimethyloctane	2067	922	968	924
16607	HC (manual)	2100			
7223	"	2109			
2895	"	2124			
2659	"	2128			
2164	dimethyldecane	2164	871	939	908
11167	HC (manual)	2173			
11519	methylundecane	2187	772	924	785

(continued)

TABLE C-17. (cont'd.)

RIC Area	Compound	Scan #	Purity	Fit	R Fit
1839	HC (manual)	2216			
1811	"	2220			
5919	$C_{12}H_{26}$ HC	2230			
9519	HC (manual)	2240			
9551	dimethyldecane	2256	905	981	908
17375	trimethylnonane	2281	924	928	825
28799	HC (manual)	2300			
8223	"	2356			
4191	"	2371			
47295	tetradecane	2399	858	963	885
5375	HC (manual)	2456			
51007	"	2798			
18143	"	2963			
	?	2992			
55551	diethyl phthalate	3026	596	979	607
86063	adhesive	3114			
22495	HC (manual)	3135			
45567	tetradecane	3191	869	975	859
3499	HC (manual)	3276			
9695	HC (manual)	3297			
4248	"	3314			
203007	hexyl acetate	3335	512	908	517
7639	?	3365			
23327	pentadecane	3405	865	961	895
19423	HC (manual)	3434			
31903	phthalate (manual)	3541			
134656	adhesive	3595			
14415	HC (manual)	3606			
84863	?	3735			
	?	3768			
12703	HC (manual)	3802			
16639	2,6-bis(1,1-dimethylethyl)phenol	3938	727	920	754
7063	HC (manual)	4022			
257	o-xylene	1802			

[a] HC = hydrocarbon.

TABLE C-18. ORGANICS IN HEADSPACE OF PT-110

RIC Area	Compound	Scan #	Purity	Fit	R Fit
544768	propane	354	884	928	885
361984	butane	372	859	867	887
10502100	dichloromethane	486	873	921	880
485376	PFT	709	dichloromethane interference		
311296	methylcyclopentane	906	937	972	939
85504	trimethyloctane	2020	848	960	859
63232	$C_{10}H_{16}$ HC (manual)	2209			
54912	tetradecane	3140	957	968	875
32832	HC[a] (manual)	3355			
164352	hexyl acetate	3685	512	919	518
11124700	chloroform	473	420	850	492
12544	trichloroethylene	1015	647	943	682
11840	tetrachloroethylene	1460	910	951	947
2480	xylene	1673	622	764	812

[a] HC = hydrocarbon.

TABLE C-19. ORGANICS IN HEADSPACE OF ARMSTRONG FISSURED MINABOARD CEILING

RIC Area	Compound	Scan #	Purity	Fit	R Fit
9407	tetramethylpentane	1751	837	948	847
1027	tetramethylpentane	1775	832	936	841
14799	ethylmethylheptane	1819	864	971	864
11039	dimethyldecane	1862	828	956	853
14448	HC[a] (manual)	1879			
5938	HC (manual)	1900			
4011	dimethyl undecane	1994	804	961	820
107264	HC (manual)	2022			
16832	HC (manual)	2055			
55872	HC (manual)	2063			
25056	HC (manual)	2078			
13024	HC (manual)	2119			
2820	HC (manual)	2127			
3552	HC (manual)	2142			
2160	HC (manual)	2174			
12512	HC (manual)	2185			
139205	HC (manual)	2213			
1412	HC (manual)	2234			
24544	HC (manual)	2253			
4368	HC (manual)	2309			
1536	HC (manual)	2323			
1048	HC (manual)	2407			
5096	HC (manual)	2668			
13040	HC (manual)	2912			
4168	HC (manual)	3000			
2280	HC (manual)	3032			
1029	chloroform (manual)	761			
764384	PFT (manual)	838			
162	benzene (manual)	924			

[a] HC = hydrocarbon.

TABLE D-1. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN BLANK (EMPTY VESSEL)

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	857	198437	1.000
	236		209054	1.053
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	887	439	.002
	97		1057	.005
	99		636	.003
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,*p*-xylene	91	NF		
	106			
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

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TABLE D-1. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	86	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-2. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN TALON G HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	842	1415	0.034
	85		1576	
PFT	186	914	41236	
	236		38490	0.93
1,2-dichloroethane	62	NF[a]		
	64			
1,1,1-trichloroethane	61	946	1384	
	97		2095	0.051
	99		1570	
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	1650	481	
	112		885	0.021
	114		216	
ethylbenzene	91	1714	652	0.016
	106		127	
m,p-xylene	91	1743	2345	0.057
	106		1174	
styrene	104	NF		
o-xylene	91	1821	1033	0.025
	106		429	

(continued)

TABLE D-2. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	2078	71120	1.725
	85		10156	
	142		71	
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-3. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN ARMSTRONG FISSURED MINABOARD CEILING HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	761	213	.002
	85	762	99	.001
PFT	186	838	122980	1.000
	236	838	119150	.969
1,2-dichloroethane	62	NF[a]		
	64			
1,1,1-trichloroethane	61	NF		
	97			
	99			
benzene	78	924	90	.001
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	NF		
	106			
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-3. (cont'd.)

Compound	**Ion**	**Scan #**	**Area**	**Ratio to PFT**
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

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[a] NF = not found.

TABLE D-4. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN FICAM (SOLID) HEADSPACE)

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	815	704	.005
	85		497	
PFT	186	889	139201	
	236		133231	.957
1,2-dichloroethane	62	NF[a]		
	64			
1,1,1-trichloroethane	61	921	73488	
	97		134764	.968
	99		86982	
benzene	78	NF		
carbon tetrachloride	117	NF		
	119	NF		
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	1703	2135	.015
	106		613	
m,*p*-xylene	91	1732	5429	.039
	106			
styrene	104			
o-xylene	91	1811	2829	.020
	106		1209	

(continued)

TABLE D-4. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	2071	50082	.360
	85		7532	
	142		----	
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

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[a] NF = not found.

TABLE D-5. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN OLD DUTCH CLEANSER HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	809	8803	.093
	85		6057	
PFT	186		94159	
	236		93345	.99
1,2-dichloroethane	62	NF[a]		
	64			
1,1,1-trichloroethane	61	915	3992	
	97		7586	.081
	99		4884	
benzene	78	968	70	.0007
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	NF		
	106			
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-5. (cont'd.)

Compound	**Ion**	**Scan #**	**Area**	**Ratio to PFT**
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	2069	72846	.774
	85		8981	
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-6. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN HEADSPACE OF CARPET GLUE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	898	49557	
	236	898	52777	
1,2-dichloroethane	62			
	64			
1,1,1-trichloroethane	61	927	2643	0.053
	97	928	5675	0.115
	99	927	3672	0.074
benzene	78	981	4209	0.085
carbon tetrachloride	117	NF		
	119	NF		
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	1705	5265	0.106
	106	1705	785	0.016
m,*p*-xylene	91	1733	10018	0.202
	106	1733	2850	0.058
styrene	104	1794	11465	0.231
o-xylene	91	1811	2160	0.044
	106	1811	755	0.015

(continued)

TABLE D-6. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

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[a] NF = not found.

TABLE D-7. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN SEVENTY-SEVEN HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	838	112	
	85		54	
PFT	186	915	83191	
	236		97642	
1,2-dichloroethane	62	NF[a]		
	64			
1,1,1-trichloroethane	61	945	157	
	97		482	
	99		303	
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	1548	121	
	166		197	
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	1718	438	
	106		149	
_m_,_p_-xylene	91	1746	1012	
	106		693	
styrene	104	NF		
_o_-xylene	91	1824	344	
	106		235	

(continued)

TABLE D-7. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	2424	6132	
	85		1365	
	156		275	
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-8. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN PT-250 HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	945	14462	1.000
	236		23331	1.613
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane (coeluted)	61	970	3276470	226.56
	97		1237000	85.53
	99		2846860	196.85
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,*p*-xylene	91	NF		
	106			
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-8. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-9. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN CARPET HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85	NF		
PFT	186	866	22789	
	236		22357	
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	NF		
	97			
	99			
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
_m,p_-xylene	91	NF		
	106			
styrene	104	NF		
_o_-xylene	91	NF		
	106			

(continued)

TABLE D-9. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-10. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN NON-SMOOTH CARPET HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	888	38943	1.000
	236		37796	0.970
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	919	407	0.010
	97		787	0.020
	99		469	0.012
benzene	78	975	1072	0.027
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	NF		
	106			
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-10. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	2457	28257	0.726
	85		7965	0.204
	156		1784	0.046
n-dodecane	57	NF		
	85			
	170			

---

[a] NF = not found.

TABLE D-11. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN SHEETROCK HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	861	28941	
	236		28836	.996
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	NF		
	97			
	99			
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	1720	365	.013
	106		53	
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-11. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	1915	13934	.481
	85		1633	
	142		50	
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-12. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN BORDON E8825 FILM HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	858	24207	1.000
	236		23897	0.987
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	892	215	0.009
	97		464	0.019
	99		271	0.011
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	NF		
	106			
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-12. (cont'd.)

Compound	**Ion**	**Scan #**	**Area**	**Ratio to PFT**
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57			
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-13. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN 650 (SURFACE APPLIED) HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	833	58204	
	236		57884	.994
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	863	17343	.298
	97		36863	.633
	99		22908	.393
benzene	78	918	403984	6.94
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	1673	656	.012
	106		282	
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-13. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57			
	85			
	156			
n-dodecane	57			
	85			
	170			

[a] NF = not found.

TABLE D-14. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN SEVENTY-SEVEN HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	816	455	0.003
	85		293	0.002
PFT	186	892	138839	1.000
	236		137226	0.988
1,2-dichloroethane	62	NF[a]		
	64			
1,1,1-trichloroethane	61	926	227	0.002
	97		535	0.004
	99		321	0.002
benzene	78	977	48048	0.418
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	1109	886	0.006
	130		918	0.007
	132		875	0.006
tetrachloroethylene	164	1532	533	0.004
	166		714	0.005
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	1732	1897	0.014
	106		1191	0.008
styrene	104	NF		
o-xylene	91	1812	691	0.005
	106		404	0.003

(continued)

TABLE D-14. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	2456	5918	0.043
	85		1317	0.009
	156		270	0.002
n-dodecane	57	2717	12600	0.091
	85		2089	0.015
	170		303	0.002

[a] NF = not found.

TABLE D-15. RELATIVE AMOUNTS OF INDOOR AIR TARGETS FROM BRILLO VC HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	791	384	.002
	85		238	.001
PFT	186	865	236631	-
	236		238008	1.006
1,2-dichloroethane	62	NF[a]		
	64			
1,1,1-trichloroethane	61	898	193	
	97		570	.002
	99		359	
benzene	78	952	2616	.011
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	1694	546519	2.310
	106		214890	.908
m,p-xylene	91	1723	342253	1.446
	106		215115	.909
styrene	104	NF		
o-xylene	91	1803	129839	.549
	106		73323	.310

(continued)

TABLE D-15. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	2169	22636	.096
	85		7385	
	142		936	
o-dichlorobenzene	146	NF		
	148			
undecane	57	2454	8269	.035
	85		2157	
	156		455	
n-dodecane	57	2716	8480	.036
	85		2506	
	170		366	

[a] NF = not found.

TABLE D-15. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	2169	22636	.096
	85		7385	
	142		936	
o-dichlorobenzene	146	NF		
	148			
undecane	57	2454	8269	.035
	85		2157	
	156		455	
n-dodecane	57	2716	8480	.036
	85		2506	
	170		366	

[a] NF = not found.

TABLE D-16. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN LEMON SPEEDWAY WAX HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	877	266920	-
	236		278211	1.042
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	909	25	
	97		266	.001
	99		166	
benzene	78	962	22019	.082
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	1096	1597	.006
	130		1474	
	132		1499	
tetrachloroethylene	164	1524	81	
	166		135	.002
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	1698	907	.003
	106		179	
m,p-xylene	91	1728	1472	.006
	106		609	
styrene	104	NF		
o-xylene	91	1808	551	.002
	106		161	

(continued)

TABLE D-16. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	2070	73816	.276
	85		9798	
	142		43	
o-dichlorobenzene	146	NF		
	148			
undecane	57	2456	2213	.009
	85		601	
	156		22	
n-dodecane	57	NF		
	85			
	170			

---

[a] NF = not found.

TABLE D-17. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN BLANK NO. 2

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	855	269963	-
	236		281116	1.041
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	NF		
	97			
	99			
benzene	78	943	934	.003
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	NF		
	130			
	132			
tetrachloroethylene	164	NF		
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	1692	1193	.004
	106		249	
m,p-xylene	91	1722	1586	.006
	106		745	
styrene	104	NF		
o-xylene	91	1802	630	.002
	106		199	

(continued)

TABLE D-17. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	1915	9119	.034
	85		852	
	142		1619	
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

TABLE D-18. RELATIVE AMOUNTS OF INDOOR AIR TARGETS IN PT-110 HEADSPACE

Compound	Ion	Scan #	Area	Ratio to PFT
chloroform	83	NF[a]		
	85			
PFT	186	788	169567	1.000
	236		91286	0.535
1,2-dichloroethane	62	NF		
	64			
1,1,1-trichloroethane	61	NF		
	97			
	99			
benzene	78	NF		
carbon tetrachloride	117	NF		
	119			
trichloroethylene	95	1015	1265	0.007
	130		2115	0.012
	132		1839	0.011
tetrachloroethylene	164	1460	2342	0.015
	166			
chlorobenzene	77	NF		
	112			
	114			
ethylbenzene	91	NF		
	106			
m,p-xylene	91	1673	1791	0.011
	106		573	0.003
styrene	104	NF		
o-xylene	91	NF		
	106			

(continued)

TABLE D-18. (cont'd.)

Compound	Ion	Scan #	Area	Ratio to PFT
1,1,2,2-tetrachloroethane	83	NF		
	166			
	168			
p-dichlorobenzene	146	NF		
	148			
decane	57	NF		
	85			
	142			
o-dichlorobenzene	146	NF		
	148			
undecane	57	NF		
	85			
	156			
n-dodecane	57	NF		
	85			
	170			

[a] NF = not found.

APPENDIX E

CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

TABLE E-1. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 1 1ST FLOOR EXTERIOR

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	0.80	0.33	1.30	0.88	0.83
1,2-DICHLOROETHANE	0.02	0.03	0.02	0.02	0.02
1,1,1-TRICHLOROETHANE	290	870	240	190	398
BENZENE	1.40	8.50	4.70	5.10	4.93
CARBON TETRACHLORIDE	0.39	0.08	0.38	0.08	0.23
TRICHLOROETHYLENE	1.60	0.05	1.20	0.98	0.96
TETRACHLOROETHYLENE	2.80	0.05	2.70	17.0	5.64
CHLOROBENZENE	0.02	0.03	0.02	0.02	0.02
STYRENE	9.50	9.00	17.0	2.20	9.43
M & P-DICHLOROBENZE	1.30	1.10	2.20	0.02	1.16
O-DICHLOROBENZENE	0.10	0.13	0.22	0.02	0.12
ETHYLBENZENE	7.50	130	110	110	89.4
O-XYLENE	19.0	340	92.0	53.0	126
M & P-XYLENE	46.0	260	170	150	157
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.02	0.02
DECANE	---	---	---	---	---
UNDECANE	---	---	---	---	---
DODECANE	---	---	---	---	---

TABLE E-2. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 1 1ST FLOOR SECRETARIAL

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	1.20	0.46	1.00	0.81	0.87
1,2-DICHLOROETHANE	0.02	0.03	0.02	0.02	0.02
1,1,1-TRICHLOROETHANE	250	630	180	230	323
BENZENE	5.70	4.40	3.00	8.50	5.40
CARBON TETRACHLORIDE	2.20	0.08	0.07	0.66	0.75
TRICHLOROETHYLENE	1.20	0.56	1.10	1.10	0.99
TETRACHLOROETHYLENE	6.20	7.70	2.70	17.0	8.40
CHLOROBENZENE	0.02	0.03	0.02	1.80	0.47
STYRENE	7.90	7.70	11.0	4.20	7.70
M & P-DICHLOROBENZE	0.89	0.52	1.50	0.64	0.89
O-DICHLOROBENZENE	0.10	0.13	0.10	0.02	0.09
ETHYLBENZENE	18.0	200	47.0	67.0	83.0
O-XYLENE	16.0	120	64.0	43.0	60.8
M & P-XYLENE	34.0	210	100	160	126
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.02	0.02
DECANE	---	290	---	570	430
UNDECANE	---	64.0	---	240	152
DODECANE	---	4.50	---	39.0	21.8

TABLE E-3. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 1 2ND FLOOR OFFICE

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	0.99	0.46	3.30	0.76	1.38
1,2-DICHLOROETHANE	0.02	0.03	0.02	0.02	0.02
1,1,1-TRICHLOROETHANE	510	470	150	540	418
BENZENE	4.70	4.40	4.60	6.50	5.05
CARBON TETRACHLORIDE	2.90	0.08	0.36	0.07	0.85
TRICHLOROETHYLENE	3.00	0.86	3.60	0.86	2.08
TETRACHLOROETHYLENE	8.10	16.0	2.00	16.5	10.7
CHLOROBENZENE	0.02	0.03	0.02	0.02	0.02
STYRENE	5.20	12.0	9.50	1.70	7.10
M & P-DICHLOROBENZE	1.80	1.10	0.02	0.62	0.89
O-DICHLOROBENZENE	0.45	0.13	0.11	0.02	0.18
ETHYLBENZENE	5.80	97.0	57.0	130	72.5
O-XYLENE	13.0	100	47.0	55.5	53.9
M & P-XYLENE	43.0	150	100	150	111
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.02	0.02
DECANE	310	---	---	320	315
UNDECANE	210	---	---	150	180
DODECANE	110	---	---	41.0	75.5

TABLE E-4. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 1 2ND FLOOR SECRETARIAL

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	1.02	0.67	0.88	0.55	0.78
1,2-DICHLOROETHANE	0.02	0.03	0.02	0.02	0.02
1,1,1-TRICHLOROETHANE	255	680	410	290	409
BENZENE	1.12	8.00	2.10	7.10	4.58
CARBON TETRACHLORIDE	0.46	0.08	0.08	0.07	0.17
TRICHLOROETHYLENE	0.42	1.10	1.30	0.51	0.83
TETRACHLOROETHYLENE	4.77	7.30	11.0	1.70	6.19
CHLOROBENZENE	0.02	0.03	0.02	0.02	0.02
STYRENE	14.0	18.0	8.20	1.90	10.5
M & P-DICHLOROBENZE	0.78	1.40	0.55	0.42	0.79
O-DICHLOROBENZENE	0.10	0.13	0.10	0.02	0.09
ETHYLBENZENE	15.0	160	55.0	120	87.5
O-XYLENE	13.0	170	39.0	64.0	71.5
M & P-XYLENE	39.0	340	97.0	160	159
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.02	0.02
DECANE	130	---	---	670	400
UNDECANE	96.0	---	---	300	198
DODECANE	38.0	---	---	44.0	41.0

TABLE E-5. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 1

3RD FLOOR COPIER ROOM

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	0.80	0.46	0.90	0.02	0.55
1,2-DICHLOROETHANE	0.02	0.02	0.02	0.02	0.02
1,1,1-TRICHLOROETHANE	250	480	135	520	346
BENZENE	1.10	3.50	2.45	5.60	3.16
CARBON TETRACHLORIDE	0.08	0.08	0.54	0.08	0.19
TRICHLOROETHYLENE	1.10	0.47	1.15	1.60	1.08
TETRACHLOROETHYLENE	2.30	4.50	2.15	1.40	2.59
CHLOROBENZENE	0.02	0.02	0.02	0.02	0.02
STYRENE	2.30	11.0	9.40	4.20	6.73
M & P-DICHLOROBENZE	1.20	9.60	1.50	1.00	3.33
O-DICHLOROBENZENE	0.11	0.12	0.11	0.02	0.09
ETHYLBENZENE	3.70	180	36.5	140	90.1
O-XYLENE	8.30	110	43.0	77.0	59.6
M & P-XYLENE	27.0	230	96.0	210	141
1,1,2,2-TETRACHLOROETHANE	0.02	0.02	0.02	0.02	0.02
DECANE	200	---	160	780	380
UNDECANE	86.0	---	92.5	320	166
DODECANE	50.0	---	44.0	56.0	50.0

TABLE E-6. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 1 OUTSIDE AIR INTAKE

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	0.71	0.16	0.49	0.15	0.38
1,2-DICHLOROETHANE	0.02	0.02	0.02	0.02	0.02
1,1,1-TRICHLOROETHANE	15.0	4.20	10.0	12.0	10.3
BENZENE	2.90	0.02	0.91	2.20	1.51
CARBON TETRACHLORIDE	1.20	0.49	0.83	0.93	0.86
TRICHLOROETHYLENE	0.60	0.05	0.21	0.22	0.27
TETRACHLOROETHYLENE	1.80	0.24	0.04	0.49	0.64
CHLOROBENZENE	0.10	0.02	0.02	0.02	0.04
STYRENE	0.10	0.47	0.02	0.02	0.15
M & P-DICHLOROBENZE	0.10	0.02	0.11	0.02	0.06
O-DICHLOROBENZENE	0.10	0.02	0.11	0.02	0.06
ETHYLBENZENE	0.97	3.70	4.10	0.81	2.40
O-XYLENE	1.20	1.60	2.20	0.66	1.42
M & P-XYLENE	3.10	0.02	0.02	1.90	1.26
1,1,2,2-TETRACHLOROETHANE	0.02	0.02	0.02	0.02	0.02
DECANE	1.50	---	---	5.60	3.55
UNDECANE	1.50	---	---	2.20	1.85
DODECANE	0.24	---	---	0.02	0.13

TABLE E-7. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 2 1ST FLOOR INTERIOR SMK/NON

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	1.10	---	1.10	2.50	1.57
1,2-DICHLOROETHANE	0.13	---	0.02	0.03	0.06
1,1,1-TRICHLOROETHANE	37.0	---	99.0	88.0	74.7
BENZENE	4.60	---	1.40	3.30	3.10
CARBON TETRACHLORIDE	0.68	---	0.90	1.10	0.89
TRICHLOROETHYLENE	18.0	---	23.0	66.0	35.7
TETRACHLOROETHYLENE	1.10	---	0.95	2.10	1.38
CHLOROBENZENE	0.03	---	0.02	0.39	0.15
STYRENE	4.30	---	5.70	2.00	4.00
M & P-DICHLOROBENZE	0.87	---	1.30	1.20	1.12
O-DICHLOROBENZENE	0.13	---	0.12	0.03	0.09
ETHYLBENZENE	2.90	---	7.00	3.20	4.37
O-XYLENE	7.40	---	8.20	3.50	6.37
M & P-XYLENE	18.0	---	21.0	9.70	16.2
1,1,2,2-TETRACHLOROETHANE	0.03	---	0.02	0.03	0.03
DECANE	32.0	---	46.0	41.0	39.7
UNDECANE	35.0	---	57.0	59.0	50.3
DODECANE	16.0	---	24.0	23.0	21.0

TABLE E-8. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 2 1ST FLOOR SECRETARIAL

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	1.50	4.40	1.50	2.50	2.48
1,2-DICHLOROETHANE	0.03	0.03	0.02	0.03	0.03
1,1,1-TRICHLOROETHANE	46.0	270	130	110	139
BENZENE	9.10	48.0	5.90	3.50	16.6
CARBON TETRACHLORIDE	0.92	1.10	1.40	1.40	1.21
TRICHLOROETHYLENE	25.0	54.0	25.0	80.0	46.0
TETRACHLOROETHYLENE	1.70	4.40	1.50	2.70	2.58
CHLOROBENZENE	0.03	0.17	0.02	0.43	0.16
STYRENE	16.0	12.0	5.50	5.40	9.73
M & P-DICHLOROBENZE	1.70	1.70	1.30	1.30	1.50
O-DICHLOROBENZENE	0.14	0.17	0.09	0.14	0.14
ETHYLBENZENE	4.70	10.0	6.90	3.40	6.25
O-XYLENE	13.0	11.0	8.10	8.40	10.1
M & P-XYLENE	15.0	27.0	19.0	20.0	20.3
1,1,2,2-TETRACHLOROETHANE	0.03	0.03	0.02	0.03	0.03
DECANE	---	61.0	44.0	46.0	50.3
UNDECANE	---	88.0	49.0	51.0	62.7
DODECANE	---	30.0	19.0	21.0	23.3

TABLE E-9. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 2

2ND FLOOR OFF/UNOCCUPIED

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	1.10	1.80	1.20	2.35	1.61
1,2-DICHLOROETHANE	0.02	0.03	0.02	0.03	0.03
1,1,1-TRICHLOROETHANE	37.0	150	66.0	76.0	82.3
BENZENE	5.60	1.20	2.30	7.40	4.13
CARBON TETRACHLORIDE	0.88	1.60	1.00	0.77	1.06
TRICHLOROETHYLENE	19.0	42.0	27.0	63.0	37.8
TETRACHLOROETHYLENE	1.90	5.20	1.10	2.15	2.59
CHLOROBENZENE	0.02	0.15	0.02	0.34	0.13
STYRENE	4.80	6.20	6.30	6.35	5.91
M & P-DICHLOROBENZE	1.00	0.99	0.83	1.10	0.98
O-DICHLOROBENZENE	0.10	0.03	0.02	0.09	0.06
ETHYLBENZENE	7.00	2.50	5.20	4.60	4.83
O-XYLENE	8.90	6.80	6.50	6.60	7.20
M & P-XYLENE	17.0	15.0	16.0	14.0	15.5
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.03	0.03
DECANE	36.0	40.0	38.0	40.0	38.5
UNDECANE	36.0	55.0	39.0	45.0	43.8
DODECANE	17.0	18.0	15.0	17.5	16.9

TABLE E-10. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 2 2ND FLOOR SECRETARIAL

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	1.23	1.50	1.40	2.20	1.58
1,2-DICHLOROETHANE	0.02	0.03	0.02	0.02	0.03
1,1,1-TRICHLOROETHANE	41.0	180	81.0	92.0	98.5
BENZENE	6.10	2.70	6.20	2.80	4.45
CARBON TETRACHLORIDE	1.05	1.60	0.58	0.80	1.01
TRICHLOROETHYLENE	17.5	43.0	23.0	73.0	39.1
TETRACHLOROETHYLENE	1.25	3.80	1.20	2.20	2.11
CHLOROBENZENE	0.02	0.03	0.78	0.57	0.35
STYRENE	9.35	8.00	7.00	5.40	7.44
M & P-DICHLOROBENZE	0.97	1.20	1.20	1.10	1.12
O-DICHLOROBENZENE	0.12	0.14	0.12	0.02	0.10
ETHYLBENZENE	7.70	6.80	8.00	6.30	7.20
O-XYLENE	9.10	7.20	9.20	6.60	8.03
M & P-XYLENE	21.0	17.0	22.0	17.0	19.3
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.02	0.03
DECANE	36.5	---	0.02	39.0	25.2
UNDECANE	37.5	---	54.0	42.0	44.5
DODECANE	18.5	---	21.0	17.0	18.8

TABLE E-11. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 2 3RD FLOOR COPIER ROOM

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	0.99	1.90	1.16	2.30	1.59
1,2-DICHLOROETHANE	0.28	0.03	0.02	0.03	0.09
1,1,1-TRICHLOROETHANE	25.0	210	103	88.0	106
BENZENE	8.10	2.50	9.70	3.70	6.00
CARBON TETRACHLORIDE	0.82	1.70	0.52	0.33	0.84
TRICHLOROETHYLENE	13.0	45.0	21.0	45.0	31.0
TETRACHLOROETHYLENE	1.00	4.40	2.10	2.50	2.50
CHLOROBENZENE	0.71	0.03	0.64	0.28	0.41
STYRENE	11.0	8.20	4.76	9.20	8.29
M & P-DICHLOROBENZE	1.00	1.60	1.20	1.30	1.28
O-DICHLOROBENZENE	0.26	0.15	0.10	0.16	0.17
ETHYLBENZENE	6.80	10.0	8.70	9.70	8.80
O-XYLENE	8.40	11.0	9.30	9.90	9.65
M & P-XYLENE	20.0	25.0	23.5	23.0	22.9
1,1,2,2-TETRACHLOROETHANE	0.03	0.03	0.02	0.03	0.03
DECANE	35.0	55.0	55.0	3.60	37.2
UNDECANE	38.0	75.0	55.0	5.40	43.4
DODECANE	18.0	25.0	21.0	0.86	16.2

TABLE E-12. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 2

OUTSIDE AIR INTAKE

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	0.76	---	0.49	---	0.63
1,2-DICHLOROETHANE	0.14	---	0.16	---	0.15
1,1,1-TRICHLOROETHANE	4.40	---	4.00	---	4.20
BENZENE	4.20	---	6.20	---	5.20
CARBON TETRACHLORIDE	0.87	---	1.30	---	1.09
TRICHLOROETHYLENE	0.07	---	0.08	---	0.07
TETRACHLOROETHYLENE	0.42	---	0.24	---	0.33
CHLOROBENZENE	0.02	---	0.13	---	0.07
STYRENE	8.20	---	0.66	---	4.43
M & P-DICHLOROBENZE	0.12	---	0.13	---	0.12
O-DICHLOROBENZENE	0.12	---	0.02	---	0.07
ETHYLBENZENE	1.20	---	1.20	---	1.20
O-XYLENE	2.40	---	1.40	---	1.90
M & P-XYLENE	2.90	---	3.60	---	3.25
1,1,2,2-TETRACHLOROETHANE	0.02	---	0.02	---	0.02
DECANE	0.02	---	1.40	---	0.71
UNDECANE	0.02	---	1.90	---	0.96
DODECANE	0.02	---	0.84	---	0.43

TABLE E-13. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 3 1ST FLOOR INTERIOR NONSMK

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	6.50	38.0	3.40	31.0	19.7
1,2-DICHLOROETHANE	0.11	0.03	0.11	0.18	0.11
1,1,1-TRICHLOROETHANE	43.0	52.0	26.0	60.0	45.3
BENZENE	4.20	11.0	3.40	6.40	6.25
CARBON TETRACHLORIDE	1.00	1.50	0.85	0.89	1.06
TRICHLOROETHYLENE	30.0	44.0	19.0	36.0	32.3
TETRACHLOROETHYLENE	1.50	4.30	1.60	3.90	2.83
CHLOROBENZENE	0.11	0.33	0.29	0.37	0.28
STYRENE	3.40	5.00	2.30	3.70	3.60
M & P-DICHLOROBENZE	0.50	0.74	0.38	0.51	0.53
O-DICHLOROBENZENE	0.02	0.03	0.02	0.03	0.03
ETHYLBENZENE	3.60	6.80	3.20	5.70	4.83
O-XYLENE	3.20	5.00	2.60	4.40	3.80
M & P-XYLENE	8.10	13.0	6.60	11.0	9.68
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.03	0.03
DECANE	5.00	5.60	3.40	5.00	4.75
UNDECANE	20.0	37.0	15.0	29.0	25.3
DODECANE	7.80	10.0	5.50	7.90	7.80

TABLE E-14. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 3 1ST FLOOR SECRETARIAL

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	12.0	20.0	2.00	4.40	9.60
1,2-DICHLOROETHANE	0.11	0.14	0.11	0.03	0.10
1,1,1-TRICHLOROETHANE	39.0	57.0	31.0	93.0	55.0
BENZENE	1.30	7.30	3.60	2.00	3.55
CARBON TETRACHLORIDE	0.59	1.00	0.78	0.29	0.67
TRICHLOROETHYLENE	19.0	43.0	18.0	51.0	32.8
TETRACHLOROETHYLENE	1.50	4.30	1.50	6.20	3.38
CHLOROBENZENE	0.11	0.14	0.11	0.25	0.15
STYRENE	3.10	4.20	2.30	4.80	3.60
M & P-DICHLOROBENZE	0.44	0.70	0.38	0.86	0.60
O-DICHLOROBENZENE	0.02	0.03	0.02	0.03	0.03
ETHYLBENZENE	3.70	6.00	3.20	6.70	4.90
O-XYLENE	3.10	4.30	2.50	5.50	3.85
M & P-XYLENE	8.20	12.0	6.80	15.0	10.5
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.03	0.03
DECANE	4.90	11.0	4.10	8.30	7.08
UNDECANE	18.0	22.0	13.0	27.0	20.0
DODECANE	6.10	6.90	4.50	8.00	6.38

TABLE E-15. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 3 2ND FLOOR OFF/OCCUPIED

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	13.0	19.0	0.95	6.35	9.83
1,2-DICHLOROETHANE	0.12	0.14	0.12	0.16	0.14
1,1,1-TRICHLOROETHANE	21.0	59.0	33.0	80.5	48.4
BENZENE	1.00	3.50	0.91	2.55	1.99
CARBON TETRACHLORIDE	0.26	0.53	0.26	0.33	0.34
TRICHLOROETHYLENE	11.0	39.0	27.0	42.0	29.8
TETRACHLOROETHYLENE	0.58	1.50	2.00	8.60	3.17
CHLOROBENZENE	0.02	0.14	0.12	0.10	0.10
STYRENE	2.40	7.20	6.00	7.45	5.76
M & P-DICHLOROBENZE	0.12	0.69	0.58	0.69	0.52
O-DICHLOROBENZENE	0.02	0.03	0.02	0.03	0.03
ETHYLBENZENE	1.60	5.20	4.40	4.95	4.04
O-XYLENE	1.10	3.50	3.30	3.60	2.88
M & P-XYLENE	2.90	8.90	8.30	9.35	7.36
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.03	0.03
DECANE	2.20	4.80	6.70	4.90	4.65
UNDECANE	3.70	9.70	11.0	9.50	8.48
DODECANE	1.40	3.90	4.50	3.70	3.38

TABLE E-16. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 3 . 2ND FLOOR SECRETARIAL

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	13.4	110	2.50	14.0	35.0
1,2-DICHLOROETHANE	0.07	0.14	0.03	0.45	0.17
1,1,1-TRICHLOROETHANE	18.0	62.0	16.0	170	66.5
BENZENE	1.60	18.0	3.30	9.20	8.03
CARBON TETRACHLORIDE	0.48	3.10	0.69	1.10	1.34
TRICHLOROETHYLENE	11.6	34.0	18.0	33.0	24.1
TETRACHLOROETHYLENE	0.62	2.40	1.10	5.80	2.48
CHLOROBENZENE	0.03	0.36	0.03	0.15	0.14
STYRENE	2.40	4.90	3.00	4.30	3.65
M & P-DICHLOROBENZE	0.22	1.10	0.39	1.40	0.78
O-DICHLOROBENZENE	0.03	0.03	0.03	0.03	0.03
ETHYLBENZENE	1.75	8.70	2.60	3.80	4.21
O-XYLENE	1.17	6.30	2.10	3.20	3.19
M & P-XYLENE	3.15	18.0	5.30	8.10	8.64
1,1,2,2-TETRACHLOROETHANE	0.03	0.03	0.03	0.03	0.03
DECANE	1.60	2.90	2.50	2.60	2.40
UNDECANE	2.50	7.50	5.70	6.60	5.58
DODECANE	0.91	2.70	2.00	2.70	2.08

TABLE E-17. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 3 3RD FLOOR COPIER ROOM

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	41.0	4.50	16.0	8.40	17.5
1,2-DICHLOROETHANE	0.28	0.13	0.14	0.26	0.20
1,1,1-TRICHLOROETHANE	34.0	16.0	15.0	54.0	29.8
BENZENE	25.0	4.40	2.80	20.0	13.1
CARBON TETRACHLORIDE	1.30	0.53	0.74	0.98	0.89
TRICHLOROETHYLENE	21.0	12.0	10.0	22.0	16.3
TETRACHLOROETHYLENE	1.30	1.70	0.98	7.80	2.95
CHLOROBENZENE	0.43	0.22	0.14	0.67	0.37
STYRENE	3.30	1.70	1.50	3.20	2.43
M & P-DICHLOROBENZE	0.42	0.34	0.27	---	0.34
O-DICHLOROBENZENE	0.03	0.03	0.03	---	0.03
ETHYLBENZENE	4.90	4.60	3.10	11.0	5.90
O-XYLENE	3.10	3.00	2.20	7.20	3.88
M & P-XYLENE	8.10	6.40	5.00	15.0	8.63
1,1,2,2-TETRACHLOROETHANE	0.03	0.03	0.03	0.03	0.03
DECANE	3.50	1.70	1.90	---	2.37
UNDECANE	8.50	4.10	4.80	---	5.80
DODECANE	3.90	2.20	2.20	---	2.77

TABLE E-18. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

OFF BLDG TRIP 3 OUTSITE AIR INTAKE

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	AVERAGE
CHLOROFORM	3.80	48.0	1.60	16.0	17.4
1,2-DICHLOROETHANE	0.11	0.17	0.02	0.04	0.09
1,1,1-TRICHLOROETHANE	1.80	6.40	0.82	4.80	3.46
BENZENE	3.90	2.80	0.66	6.00	3.34
CARBON TETRACHLORIDE	0.66	1.40	0.44	0.90	0.85
TRICHLOROETHYLENE	0.23	0.66	0.05	1.10	0.51
TETRACHLOROETHYLENE	0.45	1.30	0.38	2.40	1.13
CHLOROBENZENE	0.02	0.03	0.02	0.04	0.03
STYRENE	0.21	0.44	0.02	0.18	0.21
M & P-DICHLOROBENZE	0.02	0.17	0.12	0.18	0.12
O-DICHLOROBENZENE	0.02	0.03	0.02	0.04	0.03
ETHYLBENZENE	0.82	1.90	0.55	1.70	1.24
O-XYLENE	0.68	1.30	0.54	1.50	1.01
M & P-XYLENE	1.70	3.70	1.30	3.90	2.65
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.04	0.03
DECANE	0.02	0.03	0.02	0.18	0.06
UNDECANE	0.11	0.61	0.12	0.49	0.33
DODECANE	0.02	0.17	0.12	0.18	0.12

TABLE E-19. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

SCHOOL	GROUND FLOOR COMMON AREA						
COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.02	0.13	0.02	0.02	0.13	0.13	0.08
1,2-DICHLOROETHANE	0.06	0.02	0.02	0.02	0.02	0.02	0.03
1,1,1-TRICHLOROETHANE	6.30	11.0	13.0	18.0	120	6.60	29.2
BENZENE	10.2	9.50	15.0	7.90	4.40	4.20	8.53
CARBON TETRACHLORIDE	0.69	0.62	0.03	0.62	2.40	0.57	0.82
TRICHLOROETHYLENE	0.44	0.59	1.80	1.10	0.80	0.85	0.93
TETRACHLOROETHYLENE	2.35	8.50	8.30	4.30	1.80	4.80	5.01
CHLOROBENZENE	0.11	0.32	0.24	0.12	0.10	0.13	0.17
STYRENE	2.45	2.60	5.50	0.27	5.40	3.00	3.20
M & P-DICHLOROBENZE	1.40	1.70	3.00	1.50	0.93	1.20	1.62
O-DICHLOROBENZENE	0.11	0.22	0.10	0.12	0.10	0.13	0.13
ETHYLBENZENE	2.80	3.00	14.0	1.70	1.20	5.00	4.62
O-XYLENE	5.55	2.50	15.0	1.50	5.50	5.30	5.89
M & P-XYLENE	14.0	5.60	35.0	3.80	7.10	12.0	12.9
1,1,2,2-TETRACHLOROETHANE	0.02	0.02	0.02	0.02	0.02	0.02	0.02
DECANE	0.82	0.47	1.80	0.33	0.31	1.60	0.89
UNDECANE	0.85	0.47	1.60	0.94	0.47	0.94	0.88
DODECANE	0.74	0.47	1.40	0.71	0.55	0.64	0.75

TABLE E-20. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

SCHOOL 2ND FLOOR NEAR STAIRWAY

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.02	0.02	0.03	0.03	0.13	0.03	0.04
1,2-DICHLOROETHANE	0.17	0.02	0.02	0.02	0.02	0.02	0.05
1,1,1-TRICHLOROETHANE	7.00	11.0	9.60	11.5	84.0	11.0	22.4
BENZENE	13.0	10.0	16.0	9.20	12.0	14.0	12.4
CARBON TETRACHLORIDE	0.78	0.55	1.00	0.88	1.50	1.10	0.97
TRICHLOROETHYLENE	0.74	0.82	1.00	0.59	1.10	0.63	0.81
TETRACHLOROETHYLENE	3.20	18.0	13.0	3.45	2.30	7.10	7.84
CHLOROBENZENE	0.25	0.11	0.24	0.12	0.11	0.64	0.24
STYRENE	1.00	0.25	2.40	3.25	0.79	1.20	1.48
M & P-DICHLOROBENZE	0.72	3.10	1.40	5.45	1.10	1.30	2.18
O-DICHLOROBENZENE	0.11	0.11	0.02	0.15	0.11	0.10	0.10
ETHYLBENZENE	3.60	1.20	7.00	5.95	2.20	4.50	4.08
O-XYLENE	2.90	1.00	7.00	8.10	1.90	4.30	4.20
M & P-XYLENE	8.70	2.70	14.0	25.0	5.20	9.60	10.9
1,1,2,2-TETRACHLOROETHANE	0.02	0.02	0.02	0.02	0.02	0.02	0.02
DECANE	0.56	0.52	0.52	0.89	0.73	0.44	0.61
UNDECANE	0.65	0.48	0.57	0.97	0.60	0.85	0.69
DODECANE	1.00	0.57	0.67	0.78	0.77	1.20	0.83

TABLE E-21. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

SCHOOL	4TH FLOOR NEAR STAIRWAY						
COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.03	0.35	0.40	---	0.54	0.13	0.29
1,2-DICHLOROETHANE	0.02	0.02	0.02	---	0.02	0.02	0.02
1,1,1-TRICHLOROETHANE	9.70	7.10	7.10	---	55.0	4.20	16.6
BENZENE	10.0	5.10	5.10	---	7.05	4.00	6.25
CARBON TETRACHLORIDE	0.79	0.50	0.65	---	1.12	0.50	0.71
TRICHLOROETHYLENE	0.52	0.50	0.88	---	0.72	0.42	0.61
TETRACHLOROETHYLENE	1.80	13.0	10.0	---	2.65	4.80	6.45
CHLOROBENZENE	0.11	---	0.11	---	0.11	0.11	0.11
STYRENE	0.43	---	1.00	---	0.68	1.80	0.98
M & P-DICHLOROBENZE	1.30	---	2.30	---	2.00	2.70	2.08
O-DICHLOROBENZENE	0.11	---	0.11	---	0.11	0.11	0.11
ETHYLBENZENE	2.60	---	1.60	---	1.60	1.10	1.73
O-XYLENE	2.10	---	5.90	---	3.30	5.30	4.15
M & P-XYLENE	6.30	---	3.90	---	3.20	9.00	5.60
1,1,2,2-TETRACHLOROETHANE	0.02	---	0.02	---	0.02	0.02	0.02
DECANE	1.00	---	1.30	---	1.20	0.71	1.05
UNDECANE	0.79	---	1.40	---	0.90	0.58	0.92
DODECANE	0.71	---	0.65	---	0.81	0.62	0.70

TABLE E-22. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

SCHOOL	ROOFTOP NEAR HVAC UNIT						
COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.03	–[a]	0.02	0.14	2.20	2.00	0.88
1,2-DICHLOROETHANE	0.18	–	0.02	0.14	0.02	0.02	0.09
1,1,1-TRICHLOROETHANE	5.00	–	7.70	2.40	14.0	7.70	7.36
BENZENE	10.0	–	13.0	6.40	14.0	11.0	10.9
CARBON TETRACHLORIDE	0.86	–	0.63	0.88	1.50	0.72	0.92
TRICHLOROETHYLENE	0.11	–	0.75	0.34	1.20	0.60	0.60
TETRACHLOROETHYLENE	2.70	–	6.30	1.30	1.50	6.10	3.58
CHLOROBENZENE	0.11	–	0.10	0.03	0.22	0.12	0.12
STYRENE	1.20	–	2.50	0.14	3.40	0.12	1.47
M & P-DICHLOROBENZE	1.30	–	6.60	0.85	6.00	0.21	2.99
O-DICHLOROBENZENE	0.02	–	0.10	0.03	0.17	0.12	0.09
ETHYLBENZENE	8.70	–	11.0	0.44	7.70	0.32	5.63
O-XYLENE	7.80	–	12.0	0.37	8.60	0.02	5.78
M & P-XYLENE	20.0	–	26.0	1.10	20.0	0.24	13.5
1,1,2,2-TETRACHLOROETHANE	0.02	–	0.02	0.03	0.02	0.02	0.02
DECANE	0.27	–	0.24	1.70	0.86	0.53	0.72
UNDECANE	0.63	–	0.64	2.30	0.60	0.63	0.96
DODECANE	0.76	–	0.48	0.70	1.50	1.20	0.93

[a] Sample lost.

TABLE E-23. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 1

ROOFTOP WEST CORNER

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.65	1.40	0.67	0.85	0.63	0.84	0.84
1,2-DICHLOROETHANE	0.21	0.37	0.27	2.40	0.20	0.09	0.59
1,1,1-TRICHLOROETHANE	7.40	16.0	7.60	27.0	10.7	13.6	13.7
BENZENE	6.60	15.0	7.00	15.0	6.75	10.3	10.1
CARBON TETRACHLORIDE	0.42	0.76	0.70	0.73	0.74	0.67	0.67
TRICHLOROETHYLENE	0.19	0.55	0.34	0.33	0.25	0.28	0.32
TETRACHLOROETHYLENE	0.41	4.00	1.30	3.40	1.00	4.70	2.47
CHLOROBENZENE	0.11	0.15	0.09	0.18	0.09	0.09	0.12
STYRENE	0.20	0.63	0.47	3.80	0.67	0.42	1.03
M & P-DICHLOROBENZE	1.30	1.70	1.80	3.00	1.80	1.95	1.92
O-DICHLOROBENZENE	0.02	0.15	0.02	0.18	0.16	0.15	0.11
ETHYLBENZENE	0.33	2.40	1.50	1.80	1.70	1.95	1.61
O-XYLENE	0.29	2.30	1.60	1.70	2.00	2.05	1.66
M & P-XYLENE	0.89	6.10	4.10	4.60	4.70	4.90	4.22
1,1,2,2-TETRACHLOROETHANE	0.02	0.73	0.02	0.80	0.02	0.03	0.27
DECANE	1.20	3.60	3.40	4.50	3.30	3.55	3.26
UNDECANE	0.62	2.50	2.20	3.10	2.75	2.35	2.25
DODECANE	0.11	0.78	0.77	1.00	1.30	0.90	0.81

TABLE E-24. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 1 5TH FLOOR LOUNGE

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.96	2.60	1.20	3.90	1.80	1.60	2.01
1,2-DICHLOROETHANE	0.02	0.19	0.11	0.04	0.02	0.17	0.09
1,1,1-TRICHLOROETHANE	22.0	4.80	13.0	76.0	57.0	16.0	31.5
BENZENE	5.50	3.80	5.30	33.0	17.0	9.00	12.3
CARBON TETRACHLORIDE	0.91	0.60	0.82	0.51	0.82	0.69	0.73
TRICHLOROETHYLENE	0.54	0.72	0.60	2.00	0.82	0.70	0.90
TETRACHLOROETHYLENE	1.80	4.20	1.90	5.00	2.30	6.80	3.67
CHLOROBENZENE	0.11	0.04	0.02	0.35	0.21	0.03	0.13
STYRENE	0.65	0.56	0.02	3.30	1.50	0.80	1.14
M & P-DICHLOROBENZE	2.80	2.90	1.70	9.90	6.60	3.20	4.52
O-DICHLOROBENZENE	0.11	0.04	0.02	0.21	0.10	0.17	0.11
ETHYLBENZENE	3.30	3.50	2.20	7.00	3.20	2.90	3.68
O-XYLENE	2.80	3.20	2.20	4.50	3.20	3.10	3.17
M & P-XYLENE	8.00	9.90	6.10	18.0	8.10	7.70	9.63
1,1,2,2-TETRACHLOROETHANE	0.02	0.58	0.02	0.59	0.02	0.03	0.21
DECANE	19.0	18.0	22.0	21.0	20.0	11.0	18.5
UNDECANE	19.0	18.0	18.0	21.0	18.0	14.0	18.0
DODECANE	5.40	5.00	4.80	7.70	5.70	5.20	5.63

TABLE E-25. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 1 3RD FLOOR LOUNGE SMOKER

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	1.30	1.80	1.60	1.90	2.00	1.30	1.65
1,2-DICHLOROETHANE	0.02	0.03	0.02	0.04	0.33	0.03	0.08
1,1,1-TRICHLOROETHANE	15.0	15.0	35.0	32.0	33.0	36.0	27.7
BENZENE	7.00	12.0	13.0	13.0	12.0	13.0	11.7
CARBON TETRACHLORIDE	0.76	0.68	0.72	0.55	0.72	0.72	0.69
TRICHLOROETHYLENE	0.63	0.77	0.91	0.92	1.00	0.94	0.86
TETRACHLOROETHYLENE	2.00	3.20	2.10	3.50	2.50	6.60	3.32
CHLOROBENZENE	0.11	0.17	0.11	0.18	0.09	0.16	0.14
STYRENE	1.00	1.30	2.30	2.00	1.50	1.80	1.65
M & P-DICHLOROBENZE	9.10	7.00	8.60	9.40	8.50	6.70	8.22
O-DICHLOROBENZENE	0.11	0.17	0.11	0.18	0.09	0.16	0.14
ETHYLBENZENE	2.70	3.20	3.70	5.40	3.80	3.80	3.77
O-XYLENE	2.40	2.90	3.20	3.60	3.90	3.70	3.28
M & P-XYLENE	6.80	8.10	9.10	15.0	10.0	9.40	9.73
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.04	0.02	0.03	0.03
DECANE	25.0	22.0	29.0	7.80	27.0	11.0	20.3
UNDECANE	25.0	18.0	21.0	6.40	25.0	11.0	17.7
DODECANE	8.20	5.60	6.00	2.20	8.90	4.20	5.85

TABLE E-26. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 1 DINING ROOM

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.42	3.60	0.57	1.50	0.83	1.50	1.40
1,2-DICHLOROETHANE	0.09	0.08	0.11	0.04	2.20	0.03	0.43
1,1,1-TRICHLOROETHANE	7.95	27.8	7.60	26.0	60.0	16.0	24.2
BENZENE	3.05	17.3	4.40	18.0	7.60	10.0	10.1
CARBON TETRACHLORIDE	0.75	1.01	0.68	0.64	1.00	0.63	0.79
TRICHLOROETHYLENE	0.12	0.47	0.31	0.58	0.19	0.16	0.30
TETRACHLOROETHYLENE	0.94	3.95	1.20	4.20	1.80	3.90	2.67
CHLOROBENZENE	0.09	0.14	0.11	0.21	0.02	0.03	0.10
STYRENE	1.95	4.00	2.00	2.60	2.10	2.30	2.49
M & P-DICHLOROBENZE	0.81	3.46	0.99	4.30	1.40	2.10	2.18
O-DICHLOROBENZENE	0.09	0.14	0.36	0.21	0.08	0.41	0.21
ETHYLBENZENE	1.10	4.15	1.70	2.70	2.60	2.70	2.49
O-XYLENE	1.15	4.50	1.80	2.50	2.90	2.90	2.63
M & P-XYLENE	2.85	11.1	4.50	7.10	7.00	7.00	6.58
1,1,2,2-TETRACHLOROETHANE	0.02	0.08	0.55	0.04	0.28	0.03	0.17
DECANE	2.05	11.7	3.60	7.80	5.90	5.90	6.15
UNDECANE	1.95	18.5	3.60	5.20	9.00	6.30	7.43
DODECANE	0.99	3.90	3.60	1.90	2.10	1.80	2.38

TABLE E-27. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 1 4TH FLOOR ROOM NONSMOKER

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	1.90	1.30	2.20	3.30	1.70	2.50	2.15
1,2-DICHLOROETHANE	0.34	0.03	0.02	0.05	0.02	0.03	0.08
1,1,1-TRICHLOROETHANE	34.0	140	36.0	73.0	66.0	19.0	61.3
BENZENE	14.0	7.70	14.0	47.0	14.0	11.0	18.0
CARBON TETRACHLORIDE	0.72	0.41	0.78	0.86	0.89	0.64	0.72
TRICHLOROETHYLENE	0.47	0.44	0.68	2.00	0.51	0.29	0.73
TETRACHLOROETHYLENE	8.30	110	10.0	9.80	17.0	7.70	27.1
CHLOROBENZENE	0.11	0.03	0.18	0.24	0.09	0.16	0.14
STYRENE	1.00	0.99	1.70	2.10	1.40	1.60	1.47
M & P-DICHLOROBENZE	6.30	4.20	7.30	10.0	4.40	4.10	6.05
O-DICHLOROBENZENE	0.11	0.16	0.44	0.24	0.09	0.41	0.24
ETHYLBENZENE	2.30	6.50	3.10	4.70	3.30	2.50	3.73
O-XYLENE	2.20	7.40	3.30	4.00	3.60	2.70	3.87
M & P-XYLENE	5.50	16.0	7.90	12.0	8.20	6.10	9.28
1,1,2,2-TETRACHLOROETHANE	0.02	0.03	0.02	0.05	0.09	0.03	0.04
DECANE	21.0	94.0	18.0	15.0	38.0	8.40	32.4
UNDECANE	25.0	35.0	17.0	17.0	24.0	12.0	21.7
DODECANE	18.0	19.0	12.0	12.0	9.20	7.90	13.0

TABLE E-28. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 1

1ST FLOOR ROOM SMOKER

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	1.70	1.60	2.00	3.70	2.90	1.70	2.27
1,2-DICHLOROETHANE	0.11	0.38	0.29	0.04	0.18	0.29	0.21
1,1,1-TRICHLOROETHANE	5.50	13.0	26.0	35.0	11.0	9.00	16.6
BENZENE	5.00	15.0	12.0	21.0	6.40	11.0	11.7
CARBON TETRACHLORIDE	0.55	0.39	0.82	0.65	0.82	0.59	0.64
TRICHLOROETHYLENE	0.11	0.13	0.27	0.50	0.14	0.14	0.21
TETRACHLOROETHYLENE	0.66	1.70	1.30	1.20	0.88	2.80	1.42
CHLOROBENZENE	0.02	0.13	0.09	0.04	0.08	0.14	0.08
STYRENE	0.76	2.20	2.50	3.40	1.00	2.10	1.99
M & P-DICHLOROBENZE	0.79	2.70	4.10	5.00	1.20	2.60	2.73
O-DICHLOROBENZENE	0.11	0.13	0.09	0.21	0.08	0.14	0.13
ETHYLBENZENE	3.20	4.50	4.60	4.90	3.10	4.20	4.08
O-XYLENE	3.60	4.70	4.90	5.10	3.30	4.10	4.28
M & P-XYLENE	9.50	12.0	12.0	14.0	8.60	11.0	11.2
1,1,2,2-TETRACHLOROETHANE	0.11	0.13	0.02	2.10	0.98	0.03	0.56
DECANE	66.0	180	110	83.0	46.0	39.0	87.3
UNDECANE	53.0	140	81.0	61.0	38.0	36.0	68.2
DODECANE	12.0	17.0	16.0	13.0	9.00	9.40	12.7

TABLE E-29. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 2 1ST FLOOR COMMON AREA

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	1.10	1.20	0.95	1.80	1.20	1.09	1.22
1,2-DICHLOROETHANE	0.13	0.13	0.13	0.12	0.08	0.12	0.12
1,1,1-TRICHLOROETHANE	19.0	76.0	12.0	5.60	6.55	5.55	20.8
BENZENE	9.90	11.0	0.90	7.60	3.50	9.05	6.99
CARBON TETRACHLORIDE	0.95	1.20	1.30	2.30	1.16	0.97	1.31
TRICHLOROETHYLENE	0.57	0.57	0.24	0.91	0.59	0.93	0.64
TETRACHLOROETHYLENE	2.30	13.0	1.20	2.30	1.35	4.25	4.07
CHLOROBENZENE	0.03	0.13	0.02	0.02	0.08	0.02	0.05
STYRENE	11.0	0.03	0.02	0.02	0.51	0.25	1.97
M & P-DICHLOROBENZE	0.80	0.98	0.53	1.10	0.43	0.60	0.74
O-DICHLOROBENZENE	0.13	0.39	0.13	0.02	0.08	0.02	0.13
ETHYLBENZENE	7.50	15.0	6.00	3.90	3.00	3.95	6.56
O-XYLENE	6.40	15.0	5.50	4.10	3.00	4.80	6.47
M & P-XYLENE	15.0	36.0	16.0	9.80	8.35	11.3	16.1
1,1,2,2-TETRACHLOROETHANE	0.03	0.03	0.02	0.02	0.03	0.02	0.03
DECANE	4.00	6.30	3.10	2.70	2.15	2.30	3.43
UNDECANE	3.00	5.60	2.90	2.80	2.15	2.30	3.13
DODECANE	3.30	4.30	2.50	2.90	2.15	2.50	2.94

TABLE E-30. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 2 — 3RD FLOOR APT. NONSMOKER

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	3.40	3.20	4.90	3.20	4.20	3.80	3.78
1,2-DICHLOROETHANE	0.13	0.13	0.14	0.13	0.14	0.13	0.13
1,1,1-TRICHLOROETHANE	2.60	12.0	2.70	7.10	4.10	2.70	5.20
BENZENE	3.20	16.0	1.90	6.80	7.20	5.20	6.72
CARBON TETRACHLORIDE	1.10	1.70	1.40	2.70	1.90	0.61	1.57
TRICHLOROETHYLENE	0.06	1.00	0.66	0.82	1.10	0.26	0.65
TETRACHLOROETHYLENE	2.50	13.0	2.90	2.60	---	3.30	4.86
CHLOROBENZENE	0.13	0.13	0.03	0.03	---	0.03	0.07
STYRENE	2.50	4.00	0.03	0.03	---	0.03	1.32
M & P-DICHLOROBENZE	3.70	3.50	4.10	2.90	---	1.80	3.20
O-DICHLOROBENZENE	0.13	0.03	0.14	0.03	---	0.03	0.07
ETHYLBENZENE	3.90	9.40	3.40	2.80	---	2.80	4.46
O-XYLENE	3.70	0.03	3.70	2.80	---	3.00	2.65
M & P-XYLENE	9.20	20.0	9.00	7.00	---	7.10	10.5
1,1,2,2-TETRACHLOROETHANE	0.03	0.03	0.03	0.03	---	0.13	0.05
DECANE	1.50	2.90	2.40	1.10	---	0.78	1.74
UNDECANE	1.70	2.60	1.80	1.40	---	0.76	1.65
DODECANE	0.92	1.40	0.99	1.00	---	0.41	0.94

TABLE E-31. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 2 5TH FLOOR UNOCCUPIED APT.

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	0.53	0.66	1.20	2.10	0.99	1.70	1.20
1,2-DICHLOROETHANE	0.13	0.26	0.13	0.11	0.13	0.26	0.17
1,1,1-TRICHLOROETHANE	3.20	9.40	3.20	5.20	4.40	4.50	4.98
BENZENE	3.80	17.0	5.00	6.40	7.50	9.30	8.17
CARBON TETRACHLORIDE	1.00	2.00	2.70	1.80	1.20	0.86	1.59
TRICHLOROETHYLENE	0.42	0.84	1.00	0.79	1.20	0.51	0.79
TETRACHLOROETHYLENE	2.60	14.0	3.40	2.60	1.70	5.70	5.00
CHLOROBENZENE	0.03	0.11	0.13	0.02	0.03	0.02	0.06
STYRENE	0.03	0.69	0.66	0.02	2.70	0.29	0.73
M & P-DICHLOROBENZE	0.50	1.00	0.49	0.47	0.28	0.59	0.56
O-DICHLOROBENZENE	0.03	0.11	0.13	0.11	0.03	0.02	0.07
ETHYLBENZENE	4.20	9.60	4.30	2.70	2.80	4.70	4.72
O-XYLENE	4.80	11.0	4.70	2.80	2.90	3.10	4.88
M & P-XYLENE	11.0	21.0	11.0	6.70	7.60	12.0	11.6
1,1,2,2-TETRACHLOROETHANE	0.03	0.02	0.02	0.02	0.03	0.02	0.02
DECANE	1.80	4.30	1.70	1.20	1.00	2.00	2.00
UNDECANE	2.30	3.90	1.90	1.40	1.50	1.80	2.13
DODECANE	1.50	2.50	1.50	1.10	0.93	1.90	1.57

TABLE E-32. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 2 8TH FLOOR APT. SMOKER

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	4.10	1.50	1.30	1.80	1.90	2.30	2.15
1,2-DICHLOROETHANE	0.13	0.34	0.13	0.02	0.14	0.13	0.15
1,1,1-TRICHLOROETHANE	15.0	13.0	3.70	220	6.30	8.10	44.4
BENZENE	15.0	17.0	12.0	4.60	5.90	15.0	11.6
CARBON TETRACHLORIDE	2.50	1.70	2.10	1.30	1.70	0.88	1.70
TRICHLOROETHYLENE	0.97	0.86	0.97	0.77	1.20	0.55	0.89
TETRACHLOROETHYLENE	2.70	14.0	2.30	1.90	1.50	5.80	4.70
CHLOROBENZENE	0.13	0.13	0.13	0.12	0.14	0.13	0.13
STYRENE	2.30	3.60	0.03	0.02	0.03	2.60	1.43
M & P-DICHLOROBENZE	1.10	1.60	0.53	0.62	0.45	1.10	0.90
O-DICHLOROBENZENE	0.13	0.13	0.03	0.02	0.14	0.03	0.08
ETHYLBENZENE	7.30	10.0	4.10	3.80	4.10	7.10	6.07
O-XYLENE	6.70	11.0	3.80	3.00	3.60	6.20	5.72
M & P-XYLENE	16.0	22.0	11.0	9.80	10.0	16.0	14.1
1,1,2,2-TETRACHLOROETHANE	0.03	0.03	0.03	0.02	0.03	0.03	0.03
DECANE	3.70	6.80	2.00	3.00	1.50	3.90	3.48
UNDECANE	3.40	5.90	2.10	3.30	1.60	3.40	3.28
DODECANE	2.50	3.90	1.50	3.80	1.50	2.90	2.68

TABLE E-33. CONCENTRATION ($\mu g/m^3$) OF VOLATILE ORGANIC COMPOUNDS

ELDERLY HOME 2 OUTSIDE ON THE ROOF

COMPOUND	NIGHT 1	DAY 1	NIGHT 2	DAY 2	NIGHT 3	DAY 3	AVERAGE
CHLOROFORM	1.20	---	2.10	0.58	0.62	0.42	0.98
1,2-DICHLOROETHANE	0.13	---	0.12	0.11	0.11	0.12	0.12
1,1,1-TRICHLOROETHANE	4.50	---	7.40	1.30	1.20	1.50	3.18
BENZENE	11.0	---	6.90	2.00	2.70	4.60	5.44
CARBON TETRACHLORIDE	2.90	---	2.60	0.43	0.53	0.39	1.37
TRICHLOROETHYLENE	0.86	---	1.40	0.05	0.23	0.24	0.55
TETRACHLOROETHYLENE	2.60	---	1.50	2.10	0.79	3.60	2.12
CHLOROBENZENE	0.13	---	0.02	0.02	0.02	0.02	0.04
STYRENE	0.03	---	0.02	0.02	0.02	0.02	0.02
M % P-DICHLOROBENZE	0.46	---	0.34	0.29	0.11	0.12	0.26
O-DICHLOROBENZENE	0.13	---	0.02	0.02	0.02	0.02	0.04
ETHYLBENZENE	3.40	---	2.40	2.10	1.10	2.40	2.28
O-XYLENE	3.40	---	2.30	2.20	1.20	2.70	2.36
M % P-XYLENE	8.30	---	6.40	5.50	3.00	6.20	5.88
1,1,2,2-TETRACHLOROETHANE	0.03	---	0.02	0.02	0.02	0.02	0.02
DECANE	1.20	---	1.00	0.86	0.39	0.57	0.80
UNDECANE	0.90	---	0.75	0.78	0.32	0.33	0.62
DODECANE	0.51	---	0.39	0.33	0.19	0.19	0.32

APPENDIX F

DATA ANALYSIS FOR PESTICIDES AND PCBs

PESTICIDES/PCBs

Several types of statistical analysis were performed on the data for pesticides/PCBs collected during the indoor air study. For the initial analysis, the percentage of air samples with measurable concentrations (% above the quantifiable limit) of target pesticides/PCBs was calculated for each field monitoring trip. Then summary statistics including mean, median, and maximum concentrations were calculated for all targets which were measurable in greater than 25% of the samples. Finally, in a few selected cases correlations with sample concentrations were tested using a t-test.

Caution should be exercised in interpreting data presented for the pesticides and PCBs. Significant problems occurred during the analysis of field samples using packed column GC/ECD. Many of the field samples contained high levels of air contaminants which interfered with the analysis of the target pesticides/PCBs. This led to a number of samples which could not be quantitated. Furthermore, when the background contaminants resulting from other organics in air samples were high, identification for quantitation became subjective and may have led to significant errors.

Computer Analysis File

Before statistical analysis could be undertaken, several manipulations were necessary to process the data collected and create computer analyses files. First, several target pesticides were reported as combined values including β,γ-BHC, and heptachlor epoxide/oxychlordane to give a total of eleven pesticides/PCBs for which data are reported. Target pesticides are listed in Table F-1. A detailed description of sampling locations are given in Sections 4 and 5.

Second, the duplicate samples were averaged with their corresponding field samples. The office building trip 1 had three duplicate samples, trip 2 had two, and trip 3 had two. The school and elderly homes 1 and 2 each had two duplicate samples. The sample size for each trip to the office building (1, 2, and 3), the school building and the elderly home-2 was twelve; for the elderly home-1 it was eighteen. For computing summary statistics for each pesticide/PCBs, values below the limit of detection (LOD) were set equal to 1/2 LOD and values at trace were set equal to 5/8 QL (quantifiable limit), where 5/8 was the midpoint between the LOD and the QL.

TABLE F-1. PERCENT MEASURABLE - PESTICIDES/PCBs - OFFICE BUILDING - OVER 3 TRIPS

Compound	Percent Measurable Indoor (17-29)[a]	 Outdoor (4-6)[a]	Ratio (In/Out)
α-BHC	78.3[b]	33.3	2.4
HCB	35.0	75.0	0.5
β,γ-BHC[c]	35.3[b]	0.0	0.0
Heptachlor	76.5	100.0	0.8
Heptachlor Epoxide Oxychlordane[c]	6.9	16.7	0.4
trans-Nonachlor	10.3	16.7	0.6
p,p'-DDE	3.6	0.0	0.0
p-p'-DDD	10.3	0.0	0.0
p,p'-DDT	58.6	16.7	3.5
tech.-Chlordane	41.4	16.7	2.5
PCBs	13.8	0.0	0.0

[a] Sample size.

[b] Indicates a significant difference at 0.05 level between indoor and outdoor percent measurable - t-test.

[c] Coeluted; quantitated together.

Statistic Analysis

Percent Detected and Ratios - Office Building--

Table F-1 shows the percentage of air samples collected at the office building with measurable concentrations for each of the target pesticides/PCBs. Data is given for three trips for both indoor and outdoor samples. The indoor/outdoor ratios for percent measurable are also included. A t-test was performed between indoor and outdoor percentage measurable. There was a significant difference for α-, and γ-,β-BHC.

Of the pesticides which are greater than 25% detected, four had higher percent measurable indoors than outdoors including α-,γ-BHC, p,p'-DDT and tech.-chlordane. The reverse of this is true for HCB and heptachlor.

Tables F-2 through F-4 show percent measurable for indoor versus outdoor samples and the indoor/outdoor ratios for percent measurable for the three different trips. The tables have been reduced to six pesticides because the other five were less than 25% measurable in all three cases. Caution should be exercised in using these tables since the outdoor sample size is only two for each of the three trips.

Summary Statistics--

Tables F-5 through F-8 are the summary statistics for those pesticides/PCBs which had measurable concentrations in greater than 25% of the samples. The summary statistics are given by indoor and outdoor concentrations.

Table F-5 gives the summary statistics for three combined trips to the office building. In all cases, the indoor concentrations are higher than the outdoor concentrations for the means and in all cases, with the exception of HCB for the medians. The largest indoor/outdoor concentration ratio is 24.4 for α-BHC. Tables F-6 through F-8 are the summary statistics for the office building for trips 1, 2, and 3 computed separately. Generally, for each trip the indoor concentrations are larger than the outdoor concentrations. From trip 1 to trip 3, four of the six mean indoor concentrations and three of the six median indoor concentrations decreased. Thus there is some evidence for a decrease in concentration levels over time. For the mean concentration, HCB, β,γ-BHC, p,p'-DDT, and tech.-chlordane decreased and for the median concentrations HCB, β,γ-BHC, and p,p'-DDT decreased over time.

TABLE F-2. PERCENT MEASURABLE - PESTICIDES/PCBs - OFFICE BUILDING
TRIP 1 - INDOOR VS. OUTDOOR

Compound	Percent Measurable		Ratio (In/Out)
	Indoor (8-29)[a]	Outdoor (2)	
α-BHC	87.5	0.0	--
HCB	62.5	50.0	1.3
β,γ-BHC	62.5	0.0	--
Heptachlor	87.5	100.0	0.9
p,p'-DDT	60.0	0.0	--
tech.-Chlordane	50.0	0.0	--

[a] Sample size.

TABLE F-3. PERCENT MEASURABLE - PESTICIDES/PCBs - OFFICE BUILDING
TRIP 2 - INDOOR VS. OUTDOOR

Compound	Percent Measurable		Ratio (In/Out)
	Indoor (3-10)[a]	Outdoor (2)	
α-BHC	50.0	50.0	1.0
HCB	0.0	0.0	--
β,γ-BHC	0.0	0.0	--
Heptachlor	0.0	0.0	--
p,p'-DDT	50.0	50.0	1.0
tech.-Chlordane	40.0	50.0	0.8

[a] Sample size.

TABLE F-4. PERCENT MEASURABLE - PESTICIDES/PCBs - OFFICE BUILDING
TRIP 3 - INDOOR VS. OUTDOOR

Compound	Percent Measurable		Ratio (In/Out)
	Indoor (9)[a]	Outdoor (2)	
α-BHC	88.9	50.0	1.8
HCB	22.2	100.0	0.2
β,γ-BHC	11.1	0.0	--
Heptachlor	66.7	100.0	0.7
p,p'-DDT	66.7	0.0	--
tech.-Chlordane	33.3	0.0	--

[a] Sample size.

TABLE F-5. SUMMARY STATISTICS - PESTICIDES/PCBs - 3 TRIPS COMBINED - OFFICE BUILDING

Compound	Concentration (ng/m³) Mean[a] Indoor	Mean[a] Outdoor	Median Indoor	Median Outdoor	Max Indoor	Max Outdoor	Ratio Median (In/Out)	Ratio Max (In/Out)
α-BHC	1.9	2.9	1.2	0.05	9.6	16.	24.	0.6
HCB	1.1	0.31	0.04	0.20	7.0	0.80	0.2	8.7
β,γ-BHC	4.3	0.09	0.10	0.09	36.	0.10	1.1	360.
Heptachlor	5.8	0.83	4.3	0.57	19.	2.0	7.5	9.1
p,p'-DDT	0.79	0.17	0.17	0.07	7.5	0.69	2.4	11.
tech.-Chlordane	16.	2.2	0.15	0.14	120.	13.	1.1	9.3

[a] Indoor sample size was 17-19; outdoor sample size was 4-6.

TABLE F-6. SUMMARY STATISTICS - PESTICIDES/PCBs - TRIP 1 - OFFICE BUILDING

Compound	Concentration (ng/m³) Mean[a] Indoor	Mean[a] Outdoor	Median Indoor	Median Outdoor	Max Indoor	Max Outdoor	Ratio Median (In/Out)	Ratio Max (In/Out)
α-BHC	1.3	0.04	1.2	0.04	2.6	0.05	29.0	52.
HCB	1.4	0.42	0.26	0.42	7.0	0.80	0.6	8.7
β,γ-BHC	4.5	0.09	1.8	0.09	19.	0.10	20.	190.
Heptachlor	3.5	0.30	3.4	0.30	8.2	0.44	11.	19.
p,p'-DDT	1.4	0.07	0.56	0.07	7.5	0.08	8.0	93.
tech.-Chlordane	23.	0.13	0.13	0.38	120.	0.14	0.3	840.

[a] Indoor sample size was 8-10; outdoor sample size was 2.

TABLE F-7. SUMMARY STATISTICS - PESTICIDES/PCBs - TRIP 2 - OFFICE BUILDING

Compound	Concentration (ng/m^3)						Ratio	
	Mean[a]		Median		Max		Median	Max
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	(In/Out)	(In/Out)
α-BHC	1.3	8.0	0.51	8.0	5.2	16.	0.1	0.3
p,p'-DDT	0.50	0.38	0.13	0.38	1.5	0.69	0.3	2.2
tech.-Chlordane	18.	6.4	0.23	6.4	110.	13.	0.04	8.5

[a] Indoor sample size was 3-10; outdoor sample size was 2.

TABLE F-8. SUMMARY STATISTICS - PESTICDES/PCBs - TRIP 3 - OFFICE BUILDING

Compound	Concentration (ng/m^3)						Ratio	
	Mean[a]		Median		Max		Median	Max
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	(In/Out)	(In/Out)
α-BHC	2.9	0.54	2.0	0.54	9.6	1.04	3.7	9.2
HCB	1.1	0.20	0.04	0.20	6.3	0.22	0.2	29.
β,γ-BHC	4.1	0.09	0.99	0.09	36.	0.09	11.	400.
Heptachlor	7.9	1.4	7.3	1.4	19.	2.0	5.3	9.1
p,p'-DDT	0.43	0.07	0.17	0.07	1.8	0.07	2.4	26.
tech.-Chlordane	5.2	0.13	0.14	0.13	20.	0.13	1.1	150.

[a] Indoor sample size was 9; outdoor sample size was 2.

Percent Measurable and Ratios - Other Buildings--

Tables F-9 through F-11 show the percentage of air samples collected at the school and the two homes for the elderly with measurable concentrations of the target pesticides and PCBs. Data is given for indoor and outdoor samples separately. Indoor/outdoor ratios for percent measurable have also been calculated. Three pesticides have larger indoor than outdoor percent measurables for the school including heptachlor epoxide/oxychlordane, trans-nonachlor, and p,p'-DDT. Six of the indoor/outdoor ratios for percent measurable are less than one.

Table F-10 contains the percent measurable for indoor and outdoor samples collected at the elderly home-1 and their ratios. Five pesticides, α-BHC, β and γ-BHC, heptachlor epoxide/oxychlordane, p,p'-DDT, and p,p'-DDD, have larger indoor than outdoor percent measurable. Table F-11 contains the same data for elderly home-2. Only tech.-chlordane and PCBs have larger indoor percent measurable than outdoor.

Even though a significant difference at 0.05 level between indoor and outdoor percent measurable has been indicated in these three tables, care should be used in interpreting the results because of the very small outdoor sample size (n of 1 to 3).

Summary Statistics--

Tables F-12 through F-14 contain the summary statistics for sample concentration for the three other buildings. Again only the compounds which were measurable in greater than 25% of the samples were reported. Table F-15 lists the median QLs for samples collected at these sites.

PCBs and tech.-chlordane are an exception to this. Although samples from the elderly home-1 showed high levels of these compounds (~50 ng/m^3) in field samples, recovery data for field controls was less than 10%. Because of this problem, PCBs and tech.-chlordane could not be quantitated in samples from the the elderly home-1 and summary statistics have not been given. Again caution is urged in interpreting this data because of the small sample size for the outdoor samples. For the school building, four of the reported median concentrations are larger indoors than outdoors including heptachlor, trans-nonachlor, p,p'-DDT and tech-chlordane. For elderly home-1 this is true for the following compounds: α-BHC, β,γ-BHC,

TABLE F-9. PERCENT MEASURABLE - PESTICIDES/PCBs - SCHOOL

Compound	Percent Measurable Indoor (4-8)[a]	 Outdoor (1-3)	Ratio (In/Out)
α-BHC	87.5	100.0	0.9
HCB	33.3[b]	100.0	0.3
β,γ-BHC	0.0	0.0	--
Heptachlor	87.5	100.0	0.9
Heptachlor epoxide/ oxychlordane	40.0	33.3	1.2
trans-Nonachlor	50.0	0.0	--
p,p'-DDE	62.5	66.7	0.9
p,p'-DDD	0.0	0.0	--
p,p'-DDT	62.5[b]	0.0	--
tech.-Chlordane	62.5[b]	100.0	0.6
PCBs	37.5[b]	100.0	0.4

[a] Sample size.

[b] Indicates a significant difference at 0.05 level between indoor and outdoor percent measurable - t-test.

TABLE F-10. PERCENT MEASURABLE - PESTICIDES/PCBs - ELDERLY HOME-1

Compound	Percent Measurable Indoor (15)[a]	 Outdoor (3)	Ratio (In/Out)
α-BHC	93.3[b]	33.3	2.8
HCB	46.7	66.7	0.7
β,γ-BHC	40.0	33.3	1.2
Heptachlor	86.7	100.0	0.9
Heptachlor epoxide/ oxychlordane	20.0	0.0	--
trans-Nonachlor	26.7[b]	100.0	0.3
p,p'-DDE	66.7[b]	100.0	0.7
p,p'-DDD	20.0	0.0	--
p,p'-DDT	85.7	66.7	1.3
tech.-Chlordane	73.3[b]	100.0	0.7
PCBs	73.3[b]	100.0	0.7

[a] Sample size.

[b] Indicates a significant difference at 0.05 level between indoor and outdoor percent measurable - t-test.

TABLE F-12. SUMMARY STATISTICS - PESTICIDES/PCBs - SCHOOL

Compound	Concentration (ng/m^3)						Ratio	
	Mean[a]		Median		Max		Median	Max
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	(In/Out)	(In/Out)
α-BHC	1.1	2.4	1.0	2.4	2.4	2.5	0.4	1.0
HCB	1.2	1.0	0.05	1.0	5.5	1.0	0.05	5.4
Heptachlor	2.8	2.	2.4	1.9	6.2	2.5	1.2	2.5
Heptachlor epoxide/ oxychlordane	0.80	1.9	0.07	0.08	2.3	5.5	0.9	0.4
trans-Nonachlor	0.19	0.09	0.11	0.10	0.5	0.1	1.1	5.2
p,p'-DDE	0.30	0.79	0.30	0.30	0.6	2.0	1.0	0.3
p,p'-DDT	9.4	0.08	1.7	0.08	38.	0.09	21.	420.
tech.-Chlordane	11.	6.1	9.1	8.1	28.	9.4	1.1	3.0
PCBs	11.	5.4	0.18	5.1	62.	8.1	0.04	7.6

[a] Indoor sample size was 5-8; outdoor sample size was 1-3.

TABLE F-11. PERCENT MEASURABLE - PESTICIDES/PCBs - ELDERLY HOME-2

Compound	Percent Measurable		Ratio (In/Out)
	Indoor (6)[a]	Outdoor (3)	
α-BHC	66.7	100.0	0.7
HCB	0.0	0.0	--
β,γ-BHC	0.0	0.0	--
Heptachlor	83.3	100.0	0.8
Heptachlor epoxide/ oxychlordane	0.0	0.0	--
trans-Nonachlor	0.0	0.0	--
p,p'-DDE	83.3	100.0	0.8
p,p'-DDD	0.0	0.0	--
p,p'-DDT	66.7	100.0	0.7
tech.-Chlordane	16.7	0.0	--
PCBs	16.7	0.0	--

[a] Sample size.

TABLE F-13. SUMMARY STATISTICS - PESTICIDES/PCBs - ELDERLY HOME-1[a]

Compound	Concentration (ng/m³)						Ratio	
	Mean		Median		Max		Median	Max
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	(In/Out)	(In/Out)
α-BHC	1.1	0.19	1.0	0.04	2.4	0.49	25.	4.9
HCB	2.9	2.4	0.04	1.8	31.	5.3	0.02	5.9
β,γ-BHC	1.7	0.92	0.10	0.09	11.	2.6	1.1	4.0
Heptachlor	1.7	6.5	1.9	8.1	3.6	9.4	0.2	0.4
trans-Nonachlor	0.48	2.8	0.09	2.6	2.0	4.9	0.04	0.4
p,p'-DDE	1.1	1.3	0.62	0.77	4.6	3.0	0.8	1.5
p,p'-DDT	2.3	0.95	1.2	0.46	8.8	2.3	2.7	3.8

[a] Indoor sample size was 14-15; outdoor sample size was 3.

[b] PCBs and tech.-Chlordane were not quantitated due to low recovery in control samples.

TABLE F-14. SUMMARY STATISTICS - PESTICIDES/PCBs - ELDERLY HOME-2[a]

Compound	Concentration (ng/m³)						Ratio	
	Mean		Median		Max		Median	Max
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	(In/Out)	(In/Out)
α-BHC	1.4	0.87	1.1	1.1	4.9	1.5	1.1	3.3
β,γ-BHC	1.0	0.10	0.10	0.09	7.5	0.10	1.1	75.
Heptachlor	4.3	4.5	2.0	3.3	18.	7.3	0.6	2.5
p,p'-DDE	7.4	2.0	1.7	1.4	29.	3.4	1.2	8.5
p,p'-DDT	0.86	0.49	0.30	0.53	3.3	0.73	0.6	4.5

[a] Indoor sample size was 8; outdoor sample size was 3.

TABLE F-15. MEDIAN QLs FOR THE SCHOOL, ELDERLY HOME-1 AND ELDERLY HOME-2

Compound	Median QL (ng/m^3) School	Median QL (ng/m^3) Elderly Home 1	Median QL (ng/m^3) Elderly Home 2
α-BHC	0.47	0.32	0.36
HCB	0.36	0.29	0.31
β,γ-BHC	0.82	0.69	0.78
Heptachlor	3.0	0.39	0.46
Heptachlor epoxide	0.53	0.48	0.51
trans-Nonachlor	0.70	0.64	0.69
p,p'-DDE	0.71	0.57	0.62
p,p'-DDD	0.81	0.72	0.81
p,p'-DDT	0.64	0.54	0.62
tech.-Chlordane	1.1	1.1	1.1
PCBs	1.2	1.0	1.2

and *p*,*p*'-DDT, PCBs and tech-chlordane. In the home for the elderly-2, α-BHC, β,γ-BHC, and *p*,*p*'-DDE had large indoor/outdoor median concentration ratios.

Over the three buildings combined, 16 indoor/outdoor ratios for percent measurable were less than one (not counting those equal to 0.0) and only four greater than one. However, indoor/outdoor ratios for median concentrations were less than one in ten cases and greater than one in ten others. Therefore no clear cut pattern emerges.

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